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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/US97/13945  <b>(22) International Filing Date:</b> 7 August 1997 (07.08.97)  <b>(30) Priority Data:</b> 60/023,541 7 August 1996 (07.08.96) US 60/028,515 18 October 1996 (18.10.96) US 60/040,820 18 March 1997 (18.03.97) US  <b>(71) Applicants (for all designated States except US):</b> BIOGEN, INC. [US/US]; 14 Cambridge Center, Cambridge, MA 02142 (US). THE FACULTY OF MEDICINE OF THE UNIVERSITY OF GENEVA [CH/CH]; 1, rue M. Servet, CH-1211 Geneva 4 (CH).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> CHICHEPORTICHE, Yves [CH/CH]; 8, chemin de la fontaine, CH-1224 Chêne-Bougeries (CH). BROWNING, Jeffrey, L. [US/US]; 32 Milton Road, Brookline, MA 02146 (US).  <b>(74) Agent:</b> FLYNN, Kerry, A.; Biogen, Inc., 14 Cambridge Center, Cambridge, MA 02142 (US).	<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
<b>(54) Title:</b> A TUMOR NECROSIS FACTOR RELATED LIGAND  <b>(57) Abstract</b>  Tumor necrosis factor related ligand (TRELL), a novel member of the tumor necrosis factor family (TNF), modified TRELL, and pharmaceutical compositions comprising them.  <div style="text-align: right; font-size: 2em; font-weight: bold; margin-top: 100px;">AB</div>		

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## A TUMOR NECROSIS FACTOR RELATED LIGAND

### **BACKGROUND OF THE INVENTION**

The present invention relates to Tumor Necrosis Factor Related ligand or "TRELL", a polypeptide which is a member of the Tumor Necrosis Factor Family. The protein or its receptor may have anti-cancer and/or immunoregulatory applications. Furthermore, cells  
5 transfected with the gene for TRELL may be used in gene therapy to treat tumors, autoimmune and inflammatory diseases or inherited genetic disorders.

The invention described herein was made in part during the course of work under the grant #31-42275.94 and 32-41729.94 to Irene Garcia from the Swiss National Fund. Reserved rights described in paragraphs #28 and #29 of the Swiss National Fund statute.

### 10 **BACKGROUND OF THE INVENTION**

The tumor-necrosis factor (TNF)-related cytokines are mediators of host defense and immune regulation. Members of this family exist in membrane-anchored forms, acting locally through cell-to-cell contact, or as secreted proteins capable of diffusing to more distant targets. A parallel family of receptors signals the presence of these molecules leading to the  
15 initiation of cell death or cellular proliferation and differentiation in the target tissue. Presently, the TNF family of ligands and receptors has at least 9 recognized receptor-ligand pairs, including: TNF:TNF-R; LT- $\alpha$ :TNF-R; LT- $\alpha/\beta$ :LT- $\beta$ -R; FasL:Fas; CD40L:CD40; CD30L:CD30; CD27L:CD27; OX40L:OX40 and 4-1BBL:4-1BB. The DNA sequences encoding these ligands have only about 25% to about 30% identity in even the most related  
20 cases, although the amino acid relatedness is about 50%.

The defining feature of this family of cytokine receptors is found in the cysteine rich extracellular domain initially revealed by the molecular cloning of two distinct TNF receptors.<sup>1</sup> This family of genes encodes glycoproteins characteristic of Type I transmembrane proteins with an extracellular ligand binding domain, a single membrane  
25 spanning region and a cytoplasmic region involved in activating cellular functions. The cysteine-rich ligand binding region exhibits a tightly knit disulfide linked core domain, which,

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depending upon the particular family member, is repeated multiple times. Most receptors have four domains, although there may be as few as three, or as many as six.

Proteins in the TNF family of ligands are characterized by a short N-terminal stretch of normally short hydrophilic amino acids, often containing several lysine or arginine residues thought to serve as stop transfer sequences. Next follows a transmembrane region and an extracellular region of variable length, that separates the C-terminal receptor binding domain from the membrane. This region is sometimes referred to as the "stalk". The C-terminal binding region comprises the bulk of the protein, and often, but not always, contains glycosylation sites. These genes lack the classic signal sequences characteristic of type I membrane proteins, having type II membrane proteins with the C terminus lying outside the cell, and the short N-terminus residing in the cytoplasm. In some cases, e.g., TNF and LT- $\alpha$ , cleavage in the stalk region can occur early during protein processing and the ligand is then found primarily in secreted form. Most ligands, however, exist in a membrane form, mediating localized signalling.

The structure of these ligands has been well-defined by crystallographic analyses of TNF, LT- $\alpha$ , and CD40L. TNF and lymphotoxin- $\alpha$  (LT- $\alpha$ ) are both structured into a sandwich of two anti-parallel  $\beta$ -pleated sheets with the "jelly roll" or Greek key topology.<sup>2</sup> The rms deviation between the C $\alpha$  and  $\beta$ -strand residues is 0.61 C, suggesting a high degree of similarity in their molecular topography. A structural feature emerging from molecular studies of CD40L, TNF and LT- $\alpha$  is the propensity to assemble into oligomeric complexes. Intrinsic to the oligomeric structure is the formation of the receptor binding site at the junction between the neighboring subunits creating a multivalent ligand. The quaternary structures of TNF, CD40L and LT- $\alpha$  have been shown to exist as trimers by analysis of their crystal structures. Many of the amino acids conserved between the different ligands are in stretches of the scaffold  $\beta$ -sheet. It is likely that the basic sandwich structure is preserved in all of these molecules, since portions of these scaffold sequences are conserved across the various family members. The quaternary structure may also be maintained since the subunit conformation is likely to remain similar.

TNF family members can best be described as master switches in the immune system controlling both cell survival and differentiation. Only TNF and LT $\alpha$  are currently recognized

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as secreted cytokines contrasting with the other predominantly membrane anchored members of the TNF family. While a membrane form of TNF has been well-characterized and is likely to have unique biological roles, secreted TNF functions as a general alarm signaling to cells more distant from the site of the triggering event. Thus TNF secretion can amplify an event leading to the well-described changes in the vasculature lining and the inflammatory state of cells. In contrast, the membrane bound members of the family send signals through the TNF type receptors only to cells in direct contact. For example T cells provide CD40 mediated "help" only to those B cells brought into direct contact via cognate TCR interactions. Similar cell-cell contact limitations on the ability to induce cell death apply to the well-studied Fas system.

The ability to induce programmed cell death is an important and well-studied feature of several members of the TNF family. Fas mediated apoptosis appears to play a role in the regulation of autoreactive lymphocytes in the periphery and possibly the thymus (Castro et al., 1996) and recent work has also implicated the TNF and CD30 systems in the survival of T cells and large cell anaplastic lymphoma lines (Amakawa et al., 1996; Gruss et al., 1994; Sytwu et al., 1996; Zheng et al., 1995). We and others had previously shown the death of this line in response to TNF, Fas or LT $\alpha$  receptor signaling to have features of apoptosis (Abreu-Martin et al., 1995; Browning et al., 1996).

It appears that one can segregate the TNF ligands into three groups based on their ability to induce cell death (Table III). First, TNF, Fas ligand and TRAIL can efficiently induce cell death in many lines and their receptors mostly likely have good canonical death domains. Presumably the ligand to DR-3 (TRAMP/WSL-1) would also all into this category. Next there are those ligands which trigger a weaker death signal limited to few cell types and TRELL, CD30 ligand and LT $\alpha$ 1b2 are examples of this class. How this group can trigger cell death in the absence of a canonical death domain is an interesting question and suggests that a separate weaker death signaling mechanism exists. Lastly, there those members that cannot efficiently deliver a death signal. Probably all groups can have antiproliferative effects on some cell types consequent to inducing cell differentiation e.g. CD40 (Funakoshi et al., 1994)

The TNF family has grown dramatically in recent years to encompass at least 11 different signaling pathways involving regulation of the immune system. The expression

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patterns of TRELL and TRAIL indicate that there is still more functional variety to be uncovered in this family. This aspect has been especially highlighted in recent the discovery of two receptors that affect the ability of rous sarcoma and herpes simplex virus to replicate as well as the historical observations that TNF has anti-viral activity and pox viruses encode for decoy TNF receptors (Brojatsch et al., 1996; Montgomery et al., 1996; Smith, 1994; Vassalli, 1992). The generation soluble TRELL and the identification of the TRELL receptor should provide the tools to elucidate the biological function of this interesting protein.

TNF is a mediator of septic shock and cachexia<sup>3</sup>, and is involved in the regulation of hematopoietic cell development.<sup>4</sup> It appears to play a major role as a mediator of inflammation and defense against bacterial, viral and parasitic infections<sup>5</sup> as well as having antitumor activity.<sup>6</sup> TNF is also involved in different autoimmune diseases.<sup>7</sup> TNF may be produced by several types of cells, including macrophages, fibroblasts, T cells and natural killer cells.<sup>8</sup> TNF binds to two different receptors, each acting through specific intracellular signaling molecules, thus resulting in different effects of TNF.<sup>9</sup> TNF can exist either as a membrane bound form or as a soluble secreted cytokine.<sup>10</sup>

LT- $\alpha$  shares many activities with TNF, i.e. binding to the TNF receptors,<sup>11</sup> but unlike TNF, appears to be secreted primarily by activated T cells and some  $\beta$ -lymphoblastoid tumors.<sup>12</sup> The heteromeric complex of LT- $\alpha$  and LT- $\beta$  is a membrane bound complex which binds to the LT- $\beta$  receptor.<sup>13</sup> The LT system (LTs and LT-R) appears to be involved in the development of peripheral lymphoid organs since genetic disruption of LT- $\beta$  leads to disorganization of T and B cells in the spleen and an absence of lymph nodes.<sup>14</sup> The LT- $\beta$  system is also involved in cell death of some adenocarcinoma cell lines.<sup>15</sup>

Fas-L, another member of the TNF family, is expressed predominantly on activated T cells.<sup>16</sup> It induces the death of cells bearing its receptor, including tumor cells and HIV-infected cells, by a mechanism known as programmed cell death or apoptosis.<sup>17</sup> Furthermore, deficiencies in either Fas or Fas-L may lead to lymphoproliferative disorders, confirming the role of the Fas system in the regulation of immune responses.<sup>18</sup> The Fas system is also involved in liver damage resulting from hepatitis chronic infection<sup>19</sup> and in autoimmunity in HIV-infected patients.<sup>20</sup> The Fas system is also involved in T-cell destruction in HIV patients.<sup>21</sup> TRAIL, another member of this family, also seems to be involved in the death of a wide variety of transformed cell lines of diverse origin.<sup>22</sup>

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CD40-L, another member of the TNF family, is expressed on T cells and induces the regulation of CD40-bearing B cells.<sup>23</sup> Furthermore, alterations in the CD40-L gene result in a disease known as X-linked hyper-IgM syndrome.<sup>24</sup> The CD40 system is also involved in different autoimmune diseases<sup>25</sup> and CD40-L is known to have antiviral properties.<sup>26</sup>

5 Although the CD40 system is involved in the rescue of apoptotic B cells,<sup>27</sup> in non-immune cells it induces apoptosis<sup>28</sup>. Many additional lymphocyte members of the TNF family are also involved in costimulation.<sup>29</sup>

Generally, the members of the TNF family have fundamental regulatory roles in controlling the immune system and activating acute host defense systems. Given the current  
10 progress in manipulating members of the TNF family for therapeutic benefit, it is likely that members of this family may provide unique means to control disease. Some of the ligands of this family can directly induce the apoptotic death of many transformed cells eg. LT, TNF, Fas ligand and TRAIL (Nagata, 1997). Fas and possibly TNF and CD30 receptor activation can induce cell death in nontransformed lymphocytes which may play an immunoregulatory  
15 function (Amakawa et al., 1996; Nagata, 1997; Sytwu et al., 1996; Zheng et al., 1995). In general, death is triggered following the aggregation of death domains which reside on the cytoplasmic side of the TNF receptors. The death domain orchestrates the assembly of various signal transduction components which result in the activation of the caspase cascade (Nagata, 1997). Some receptors lack canonical death domains, e.g. LT $\beta$  receptor and CD30  
20 (Browning et al., 1996; Lee et al., 1996) yet can induce cell death, albeit more weakly. It is likely that these receptors function primarily to induce cell differentiation and the death is an aberrant consequence in some transformed cell lines, although this picture is unclear as studies on the CD30 null mouse suggest a death role in negative selection in the thymus (Amakawa et al., 1996). Conversely, signaling through other pathways such as CD40 is  
25 required to maintain cell survival. Thus, there is a need to identify and characterize additional molecules which are members of the TNF family thereby providing additional means of controlling disease and manipulating the immune system.

### **SUMMARY OF THE INVENTION**

Accordingly, the present invention is directed to a polypeptide, a tumor necrosis factor  
30 related ligand called TRELL which substantially obviates one or more of the problems due to

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the limitations and disadvantages of the related art. The inventor has discovered a new member of the TNF family of cytokines, and defined both the human and murine amino acid sequence of the protein, as well as the DNA sequences encoding these protein. The claimed invention may be used to identify new diagnostics and therapeutics for numerous diseases and conditions as discussed in more detail below, as well as to obtain information about, and manipulate, the immune system and its processes. Additionally, the claimed invention is involved in the induction of cell death in carcinoma.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the compositions and methods particularly pointed out in the written description and claims hereof, as well as in the appended drawings.

Thus, to achieve these and other advantages, and in accordance with the purpose of the invention, as embodied and broadly described herein, the invention includes a DNA sequence encoding TRELL. The nucleotide sequence for mouse TRELL (mTRELL) is shown in SEQ ID. NO. 1, and for human TRELL (hTRELL) in SEQ ID. NO. 3. Specifically, the invention relates to DNA sequences which encode a TRELL having the amino acid sequence identified in SEQ. ID. NO. 2 (mTRELL) or 4 (hTRELL). In other embodiments, the invention relates to sequences that have at least 50% homology with the DNA encoding the C terminal receptor binding domain of TRELL and hybridize to the claimed DNA sequences or fragments thereof, and which encode TRELL having the sequence identified in SEQ. ID. NO. 4 or SEQ ID. NO. 2.

The invention in certain embodiments furthermore relates to a DNA sequence encoding TRELL where the sequence is operatively linked to an expression control sequence.

Any suitable expression control sequence is useful in the claimed invention, and can easily be selected by one skilled in the art.

The invention also contemplates a recombinant DNA comprising a sequence encoding TRELL, or a fragment thereof, as well as hosts with stably integrated TRELL sequences introduced into their genome, or possessing episomal elements. Any suitable host may be used in the invention, and can easily be selected by one skilled in the art without undue experimentation.

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In other embodiments, the invention relates to methods of producing substantially pure TRELL comprising the step of culturing transformed hosts, and TRELL essentially free of normally associated animal proteins.

5 The invention encompasses TRELL having the amino acid sequence identified in SEQ. ID. NO. 4 or SEQ ID. NO. 2 as well as fragments or homologs thereof. In various embodiments, the amino acid and/or the DNA sequence of TRELL may comprise conservative insertions, deletions and substitutions, as further defined below or may comprise fragments of said sequences.

10 The invention relates in other embodiments to soluble TRELL constructs, which may be used to directly trigger TRELL mediated pharmacological events. Such events may have useful therapeutic benefit in the treatment of cancer or the manipulation of the immune system to treat immunologic diseases. Soluble TRELL forms could be genetically reengineered to incorporate an easily recognizable tag, thereby facilitating the identification of TRELL receptors.

15 In yet other embodiments the invention relates to methods of gene therapy using the TRELL's disclosed and claimed herein.

The pharmaceutical preparations of the invention may, optionally, include pharmaceutically acceptable carriers, adjuvants, fillers, or other pharmaceutical compositions, and may be administered in any of the numerous forms or routes known in the art.

20 It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory, and are intended to provide further explanation of the invention as claimed.

The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in, and constitute a part of this specification, illustrate several 25 embodiments of the invention, and together with the description serve to explain the principles of the invention.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is an amino acid sequence comparison of human and mouse TRELL.

30 Figures 2A and 2B are an amino acid comparison of human members of the TNF family.

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Figure 3 is a northern analysis of TRELL mRNA expression in different mouse cell lines and tissues. Lanes are duplicated and contained RNA from (1) thioglycolate induced peritoneal macrophages, (2) bone marrow, (3) spleen, and (4) liver.

Figure 4 is a northern analysis of TRELL mRNA expression in different human tissues.

Figure 5: SDS-PAGE of recombinant TNF, LT $\alpha$  and TRELL under reducing and nonreducing conditions.

Figure 6: TRELL is cytotoxic to the human adenocarcinoma line HT29.

A. Ability of the TNF, TRELL, LT $\alpha$ / $\beta$  and anti-Fas to block the growth of the HT29 line in the presence of human interferon-g. Cells were grown for 4 days in the presence of the various agents and growth was assessed using MTT staining.

B. Morphology of the cells undergoing cell death. Cells were pregrown for 2 days and then treated for 24 hours with 80 U/ml interferon-g and A. no further addition, B. 100 ng/ml fixed with ethanol and shown by phase contrast microscopy in the top panels (400x magnification) and stained with 1  $\mu$ g/ml Hoescht dye to reveal the nuclei in the bottom panel. Typical cells with condensed nuclei characteristic of apoptosis are indicated with arrows.

## DETAILED DESCRIPTION

Reference will now be made in detail to the present preferred embodiments of the invention. This invention relates to DNA sequences that code for human or mouse TRELL, fragments and homologs thereof, and expression of those DNA sequences in hosts transformed with them. The invention relates to uses of these DNA sequences and the peptides encoded by them. Additionally, the invention encompasses both human and mouse amino acid sequences for TRELL, or fragments thereof, as well as pharmaceutical compositions comprising or derived from them.

### A. DEFINITIONS

"Homologous", as used herein, refers to the sequence similarity between sequences of molecules being compared. When a position in both of the two compared sequences is occupied by the same base or amino acid monomer subunit, e.g., if a position in each of two DNA molecules is occupied by adenine, then the molecules are homologous at that position.

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The percent of homology between two sequences is a function of the number of matching or homologous positions shared by the two sequences divided by the number of positions compared x 100. For example, if 6 of 10, of the positions in two sequences are matched or homologous then the two sequences are 60% homologous. By way of example, the DNA sequences ATTGCC and TATGGC share 50% homology. Generally, a comparison is made when two sequences are aligned to give maximum homology.

A "purified preparation" or a "substantially pure preparation" of a polypeptide, as used herein, means a polypeptide that has been separated from other proteins, lipids, and nucleic acids with which it naturally occurs. Preferably, the polypeptide is also separated from other substances, e.g., antibodies, matrices, etc., which are used to purify it.

"Transformed host" as used herein is meant to encompass any host with stably integrated sequence, i.e. TRELL sequence, introduced into its genome or a host possessing sequence, i.e. TRELL, encoding episomal elements.

A "treatment", as used herein, includes any therapeutic treatment, e.g., the administration of a therapeutic agent or substance, e.g., a drug.

A "substantially pure nucleic acid", e.g., a substantially pure DNA, is a nucleic acid which is one or both of: not immediately contiguous with either one or both of the sequences, e.g., coding sequences, with which it is immediately contiguous (i.e., one at the 5' end and one at the 3' end) in the naturally-occurring genome of the organism from which the nucleic acid is derived; or (2) which is substantially free of a nucleic acid sequence with which it occurs in the organism from which the nucleic acid is derived. The term includes, for example, a recombinant DNA which is incorporated into a vector, e.g., into an autonomously replicating plasmid or virus, or into the genomic DNA of a prokaryote or eukaryote, or which exists as a separate molecule (e.g., a cDNA or a genomic DNA fragment produced by PCR or restriction endonuclease treatment) independent of other DNA sequences. Substantially pure DNA also includes a recombinant DNA which is part of a hybrid gene encoding TRELL.

The terms "peptides", "proteins", and "polypeptides" are used interchangeably herein.

"Biologically active" as used herein, means having an in vivo or in vitro activity which may be performed directly or indirectly. Biologically active fragments of TRELL may have, for example, 70% amino acid homology with the active site of TRELL, more preferably at least 80%, and most preferably, at least 90% homology. Identity or homology with respect

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to TRELL is defined herein as the percentage of amino acid residues in the candidate sequence which are identical to the TRELL residues in SEQ. ID. NOS. 2 or 4.

The practice of the present invention will employ, unless otherwise indicated, conventional techniques of cell biology, cell culture, molecular biology, transgenic biology, microbiology, recombinant DNA, and immunology, which are within the skill of the art. Such techniques are described in the literature.<sup>30</sup>

#### B. DNA SEQUENCES OF THE INVENTION

As described herein, one aspect of the invention features a substantially pure (or recombinant) nucleic acid which includes a nucleotide sequence encoding a TRELL polypeptide, such as the DNA described in SEQ. ID. NO. 1 or 3 and/or equivalents of such nucleic acids. The term nucleic acid as used herein can include fragments and equivalents, such as, for example, sequences encoding functionally equivalent peptides. Equivalent nucleotide sequences may include sequences that differ by one or more nucleotide substitutions, additions or deletions, such as allelic variants, mutations, etc. and include sequences that differ from the nucleotide sequence encoding TRELL shown in SEQ ID NO:1 or 3, due to the degeneracy of the genetic code. The inventors have sequenced a human 1936 bp DNA which contains an open reading frame encoding a TRELL polypeptide, having the 248 amino acid sequence as identified in SEQ. ID. NO. 4.

The inventor describes herein both human and murine sequences; the invention will be described generally by reference to the human sequences, although one skilled in the art will understand that the mouse sequences are encompassed herein. A striking feature of TRELL is the extensive sequence conservation of the receptor binding domain between mouse and man; only the Fas ligand approaches this level of conservation. Both the murine and human TRELL proteins have all of the characteristics of the TNF family, i.e., a type II membrane protein organization and conservation of the sequence motifs involved in the folding of the protein into the TNF ant-parallel  $\beta$ -sheet structure.

The nucleotide sequence for mTRELL is set forth in SEQ. ID. NO. 1; the amino acid sequence for mTRELL is described in SEQ. ID. NO. 2. The DNA and amino acid sequences for hTRELL are described in SEQ. ID. NOS. 3 and 4 respectively.

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The sequences of the invention can be used to prepare a series of DNA probes that are useful in screening various collections of natural and synthetic DNAs for the presence of DNA sequences that code for TRELL or fragments or derivatives thereof. One skilled in the art will recognize that reference to "TRELL", as used herein, refers also to biologically active derivatives, fragments or homologs thereof.

The DNA sequences encoding TRELL of the invention can be employed to produce TRELL peptides on expression in various prokaryotic and eukaryotic hosts transformed with them. These TRELL peptides may be used in anti-cancer, and immunoregulatory applications. In general, this comprises the steps of culturing a host transformed with a DNA molecule containing the sequence encoding TRELL, operatively-linked to an expression control sequence.

The DNA sequences and recombinant DNA molecules of the present invention can be expressed using a wide variety of host/vector combinations. For example, useful vectors may consist of segments of chromosomal, non-chromosomal or synthetic DNA sequences. The expression vectors of the invention are characterized by at least one expression control sequence that may be operatively linked to a TRELL DNA sequence inserted in the vector, in order to control and to regulate the expression of the DNA sequence.

Furthermore, within each expression vector, various sites may be selected for insertion of a TRELL sequence of the invention. The sites are usually designated by a restriction endonuclease which cuts them, and these sites and endonucleases are well recognized by those skilled in the art. It is of course to be understood that an expression vector useful in this invention need not have a restriction endonuclease site for insertion of the desired DNA fragment. Instead, the vector may be cloned to the fragment by alternate means. The expression vector, and in particular the site chosen therein for insertion of a selected DNA fragment, and its operative linking therein to an expression control sequence, is determined by a variety of factors. These factors include, but are not limited to, the size of the protein to be expressed, the susceptibility of the desired protein to proteolytic degradation by host cell enzymes, number of sites susceptible to a particular restriction enzyme, contamination or binding of the protein to be expressed by host cell proteins which may prove difficult to remove during purification. Additional factors which may be considered include expression characteristics such as the location of start and stop codons relative to the vector sequences,

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and other factors which will be recognized by those skilled in the art. The choice of a vector and insertion site for the claimed DNA sequences is determined by a balancing of these factors, not all selections being equally effective for a desired application. However, it is routine for one skilled in the art to analyze these parameters and choose an appropriate system depending on the particular application.

One skilled in the art can readily make appropriate modifications to the expression control sequences to obtain higher levels of protein expression, i.e. by substitution of codons, or selecting codons for particular amino acids that are preferentially used by particular organisms, to minimize proteolysis or to alter glycosylation composition. Likewise, cysteines may be changed to other amino acids to simplify production, refolding or stability problems.

Thus, not all host/expression vector combinations function with equal efficiency in expressing the DNA sequences of this invention. However, a particular selection of a host/expression vector combination may be made by those of skill in the art. Factors one may consider include, for example, the compatibility of the host and vector, toxicity to the host of the proteins encoded by the DNA sequence, ease of recovery of the desired protein, expression characteristics of the DNA sequences and expression control sequences operatively linked to them, biosafety, costs and the folding, form or other necessary post-expression modifications of the desired protein.

The TRELL and homologs thereof produced by hosts transformed with the sequences of the invention, as well as native TRELL purified by the processes of this invention, or produced from the claimed amino acid sequences, are useful in a variety of compositions and methods for anticancer and immunoregulatory applications. They are also useful in therapy and methods directed to other diseases.

This invention also relates to the use of the DNA sequences disclosed herein to express TRELL under abnormal conditions, i.e. in a gene therapy setting. TRELL may be expressed in tumor cells under the direction of promoters appropriate for such applications. Such expression could enhance anti-tumor immune responses or directly affect the survival of the tumor. Cytokines such as TRELL can also affect the survival of an organ graft by altering the local immune response. In this case, the graft itself or the surrounding cells would be modified with an engineered TRELL gene.

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Another aspect of the invention relates to the use of the isolated nucleic acid encoding TRELL in "antisense" therapy. As used herein, "antisense" therapy refers to administration or *in situ* generation of oligonucleotides or their derivatives which specifically hybridize under cellular conditions with the cellular mRNA and/or DNA encoding TRELL, so as to inhibit expression of the encoded protein, i.e. by inhibiting transcription and/or translation. The binding may be by conventional base pair complementarity, or, for example, in the case of binding to DNA duplexes, through specific interactions in the major groove of the double helix. In general, "antisense" therapy refers to a range of techniques generally employed in the art, and includes any therapy which relies on specific binding to oligonucleotide sequences.

An antisense construct of the present invention can be delivered, for example, as an expression plasmid, which, when transcribed in the cell, produces RNA which is complementary to at least a portion of the cellular mRNA which encodes TRELL. Alternatively, the antisense construct can be an oligonucleotide probe which is generated *ex vivo*. Such oligonucleotide probes are preferably modified oligonucleotides which are resistant to endogenous nucleases, and are therefore stable *in vivo*. Exemplary nucleic acid molecules for use as antisense oligonucleotides are phosphoramidates, phosphothioate and methylphosphonate analogs of DNA (See, e.g., 5,176,996; 5,264,564; and 5,256,775). Additionally, general approaches to constructing oligomers useful in antisense therapy have been reviewed, for example, by Van Der Krol et al., (1988) *Biotechniques* 6:958-976; and Stein et al. (1988) *Cancer Res* 48: 2659-2668, specifically incorporated herein by reference.

### C. TRELL AND ITS AMINO ACID SEQUENCES

The Tumor Necrosis Factor Family Related Protein (TRELL) of the invention, as discussed above, is a member of the TNF family. The protein, fragments or homologs thereof may have wide therapeutic and diagnostic applications.

TRELL is present in many tissues, in a pattern that is relatively unique among members of the TNF family. Since members of the TNF family are involved in the regulation of a cell death and survival, and cell differentiation, it is possible that TRELL is also involved in cell survival, differentiation, and repair in various tissues.

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Although the precise three dimensional structure of TRELL is not known, it is predicted that, as a member of the TNF family, it may share certain structural characteristics with other members of the family. Both mouse and human TRELL are disclosed herein. Mouse TRELL, as deduced from the existing cDNA sequence, comprises a stretch of at least 21 hydrophobic amino acids, which presumably acts as a membrane anchoring domain for a type II membrane protein. The amino acid sequence of mTRELL is described in SEQ ID. NO. 2.

Human TRELL comprises an N-terminal hydrophilic cytoplasmic domain, a roughly 27 amino acid hydrophobic, transmembrane type II domain and a 204 amino acid extracellular domain. The amino acid sequence of hTRELL is described in SEQ. ID. NO. 4.

Figure 1 depicts an amino acid sequence comparison of human and mouse TRELL.

While a 52 amino acid N-terminal region can be predicted from an open reading frame in the cDNA clone, the exact starting methionine cannot be predicted. Met-36 has a reasonable consensus Kozak sequence which may make it the preferred starting codon.

Comparison of the TRELL sequence with other members of the human TNF family reveals considerable structural similarity. For example, as can be seen in Figures 2A and 2B, all the proteins resemble Type II membrane proteins, and share several regions of sequence conservation in the extracellular domain. Regions with bars over the sequences indicate those sequences in TNF and LT $\alpha$  involved in a  $\beta$  strand organization of the molecules. Putative N-linked glycosylation sites are underlined. Asterisks indicate the cysteines involved in a disulfide linkage in TNF. The conserved domains are likely to be involved in intersubunit interactions and sheet organization.

An EST search revealed a human clone of 345 bases which is highly homologous to the mouse TRELL. A human TRELL amino acid sequence is set forth in SEQ.ID. NO. 4. The open reading frames encoded by the EST do not contain the sequence motifs which would allow one to characterize this sequence as a member of the TNF family of ligands, e.g. the motif used by Wiley et al. to identify a TRAIL EST within the existing database.

The novel polypeptides of the invention specifically interact with a receptor, which has not yet been identified. However, the peptides and methods disclosed herein enable the identification of receptors which specifically interact with TRELL or fragments thereof.

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The claimed invention in certain embodiments includes peptides derived from TRELL which have the ability to bind with TRELL receptors. Fragments of TRELL can be produced in several ways, e.g., recombinantly, by PCR, proteolytic digestion or by chemical synthesis. Internal or terminal fragments of a polypeptide can be generated by removing one or more  
5 nucleotides from one end or both ends of a nucleic acid which encodes the polypeptide. Expression of the mutagenized DNA produces polypeptide fragments. Digestion with "end-nibbling" endonucleases can thus generate DNA's which encode a variety of fragments. DNA's which encode fragments of a protein can also be generated by random shearing, restriction digestion or a combination of the above discussed methods.

10 Polypeptide fragments can also be chemically synthesized using techniques known in the art such as conventional Merrifield solid phase f-moc or t-boc chemistry. For example, peptides and DNA sequences of the present invention may be arbitrarily divided into fragments of desired length with no overlap of the fragment, or divided into overlapping fragments of a desired length. Methods such as these are described in more detail below.

#### 15 D. Generation of Soluble TRELL

Soluble forms of the ligand can often signal effectively and hence can be administered as a drug which now mimics the natural membrane form. It is possible that TRELL is naturally secreted as a soluble cytokine, however, if it is not, one can reengineer the gene to force secretion. To create a soluble secreted form of TRELL, one would remove at the DNA  
20 level the N-terminus transmembrane regions, and some portion of the stalk region, and replace them with a type I leader or alternatively a type II leader sequence that will allow efficient proteolytic cleavage in the chosen expression system. A skilled artisan could vary the amount of the stalk region retained in the secretion expression construct to optimize both receptor binding properties and secretion efficiency. For example, the constructs containing all  
25 possible stalk lengths, i.e. N-terminal truncations, could be prepared such that proteins starting at amino acids 81 to 139 would result. The optimal length stalk sequence would result from this type of analysis.

#### E. Generation of Antibodies Reactive with TRELL

The invention also includes antibodies specifically reactive with TRELL or its  
30 receptor. Anti-protein/anti-peptide antisera or monoclonal antibodies can be made by

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standard protocols (See, for example, *Antibodies: A Laboratory Manual* ed. by Harlow and Lane (Cold Spring Harbor Press: 1988)). A mammal such as a mouse, a hamster or rabbit can be immunized with an immunogenic form of the peptide. Techniques for conferring immunogenicity on a protein or peptide include conjugation to carriers, or other techniques, well known in the art.

An immunogenic portion of TRELL or its receptor can be administered in the presence of an adjuvant. The progress of immunization can be monitored by detection of antibody titers in plasma or serum. Standard ELISA or other immunoassays can be used with the immunogen as antigen to assess the levels of antibodies.

In a preferred embodiment, the subject antibodies are immunospecific for antigenic determinants of TRELL or its receptor, e.g. antigenic determinants of a polypeptide of SEQ ID NO: 2 or 4, or a closely related human or non-human mammalian homolog (e.g. 70, 80 or 90 percent homologous, more preferably at least 95 percent homologous). In yet a further preferred embodiment of the present invention, the anti-TRELL or anti-TRELL-receptor antibodies do not substantially cross react (i.e. react specifically) with a protein which is e.g., less than 80 percent homologous to SEQ ID NO 2 or 4; preferably less than 90 percent homologous with SEQ ID NO: 2 or 4; and, most preferably less than 95 percent homologous with SEQ ID NO: 2 or 4. By "not substantially cross react", it is meant that the antibody has a binding affinity for a non-homologous protein which is less than 10 percent, more preferably less than 5 percent, and even more preferably less than 1 percent, of the binding affinity for a protein of SEQ ID NO 2 or 4.

The term antibody as used herein is intended to include fragments thereof which are also specifically reactive with TRELL or TRELL-receptor. Antibodies can be fragmented using conventional techniques and the fragments screened for utility in the same manner as described above for whole antibodies. For example,  $F(ab')_2$  fragments can be generated by treating antibody with pepsin. The resulting  $F(ab')_2$  fragment can be treated to reduce disulfide bridges to produce Fab' fragments. The antibodies of the present invention are further intended to include biospecific and chimeric molecules having anti-TRELL or anti-TRELL-receptor activity. Thus, both monoclonal and polyclonal antibodies (Ab) directed against TRELL and its receptor, and antibody fragments such as Fab' and  $F(ab')_2$ , can be used to block the action of TRELL and its receptor.

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Various forms of antibodies can also be made using standard recombinant DNA techniques. (Winter and Milstein, Nature 349: 293-299 (1991) specifically incorporated by reference herein.) For example, chimeric antibodies can be constructed in which the antigen binding domain from an animal antibody is linked to a human constant domain (e.g. Cabilly et al., U.S. 4,816,567, incorporated herein by reference). Chimeric antibodies may reduce the observed immunogenic responses elicited by animal antibodies when used in human clinical treatments.

In addition, recombinant "humanized antibodies" which recognize TREL or its receptor can be synthesized. Humanized antibodies are chimeras comprising mostly human IgG sequences into which the regions responsible for specific antigen-binding have been inserted. Animals are immunized with the desired antigen, the corresponding antibodies are isolated, and the portion of the variable region sequences responsible for specific antigen binding are removed. The animal-derived antigen binding regions are then cloned into the appropriate position of human antibody genes in which the antigen binding regions have been deleted. Humanized antibodies minimize the use of heterologous (i.e. inter species) sequences in human antibodies, and thus are less likely to elicit immune responses in the treated subject.

Construction of different classes of recombinant antibodies can also be accomplished by making chimeric or humanized antibodies comprising variable domains and human constant domains (CH1, CH2, CH3) isolated from different classes of immunoglobulins. For example, antibodies with increased antigen binding site valencies can be recombinantly produced by cloning the antigen binding site into vectors carrying the human : chain constant regions. (Arulanandam et al., J. Exp. Med., 177: 1439-1450 (1993), incorporated herein by reference.)

In addition, standard recombinant DNA techniques can be used to alter the binding affinities of recombinant antibodies with their antigens by altering amino acid residues in the vicinity of the antigen binding sites. The antigen binding affinity of a humanized antibody can be increased by mutagenesis based on molecular modeling. (Queen et al., Proc. Natl. Acad. Sci. 86: 10029-33 (1989) incorporated herein by reference.

E. Generation of Analogs: Production of Altered DNA and Peptide Sequences

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5       Analogues of TRELL can differ from the naturally occurring TRELL in amino acid sequence, or in ways that do not involve sequence, or both. Non-sequence modifications include in vivo or in vitro chemical derivatization of TRELL. Non-sequence modifications include, but are not limited to, changes in acetylation, methylation, phosphorylation, carboxylation or glycosylation.

          Preferred analogues include TRELL or biologically active fragments thereof, whose sequences differ from the sequence given in SEQ ID NOS. 2 and 4, by one or more conservative amino acid substitutions, or by one or more non-conservative amino acid substitutions, deletions or insertions which do not abolish the activity of TRELL.

10       Conservative substitutions typically include the substitution of one amino acid for another with similar characteristics, e.g. substitutions within the following groups: valine, glycine; glycine, alanine; valine, isoleucine, leucine; aspartic acid, glutamic acid; asparagine, glutamine; serine, threonine; lysine, arginine; and, phenylalanine, tyrosine.

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TABLE I  
CONSERVATIVE AMINO ACID REPLACEMENTS

for amino Acid	code	replace with any of:
Alanine	A	D-Ala, Gly, Beta-Ala, L-Cys, D-Cys
Arginine	R	D-Arg, Lys, D-Lys, homo-Arg, D-homo-Arg, Met, Ile, D-Met, D-Ile, Orn, D-Orn
Asparagine	N	D-Asn, Asp, D-Asp, Glu, D-Glu, Gln, D-Gln
Aspartic Acid	D	D-Asp, D-Asn, Asn, Glu, D-Glu, Gln, D-Gln
Cysteine	C	D-Cys, S-Me-Cys, Met, D-Met, Thr, D-Thr
Glutamine	Q	D-Gln, Asn, D-Asn, Glu, D-Glu, Asp, D-Asp
Glutamic Acid	E	D-Glu, D-Asp, Asp, Asn, D-Asn, Gln, D-Gln
Glycine	G	Ala, D-Ala, Pro, D-Pro, -Ala, Acp
Isoleucine	I	D-Ile, Val, D-Val, Leu, D-Leu, Met, D-Met
Leucine	L	D-Leu, Val, D-Val, Leu, D-Leu, Met, D-Met

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Lysine	K	D-Lys, Arg, D-Arg, Homo-arg, D-homo-Arg, Met, D-Met, Ile, D-Ile, Orn, D-Orn
Methionine	M	D-Met, S-Me-Cys, Ile, D- Ile, Leu, D-Leu, Val, D- Val
Phenylalanine	F	D-Phe, Tyr, D-Thr, L- Dopa, His, D-His, Trp, D- Trp, Trans-3, 4 or 5- phenylproline, cis-3, 4, or 5-phenylproline
Proline	P	D-Pro, L-I-thoazolidine-4- carboxylic acid, D-or L-1- oxazolidine-4-carboxylic acid
Serine	S	D-Ser, Thr, D-Thr, allo- Thr, Met, D-Met, Met(O), D-Met(O), L-Cys, D-Cys
Threonine	T	D-Thr, Ser, D-Ser, allo- Thr, Met, D-Met, Met(O), D-Met(O), Val, D-Val
Tyrosine	Y	D-Tyr, Phe, D-Phe, L- Dopa, His, D-His
Valine	V	D-Val, Leu, D-Leu, Ile, D- Ile, Met, D-Met

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Useful methods for mutagenesis include PCR mutagenesis and saturation mutagenesis as discussed in more detail below. A library of random amino acid sequence variants can also be generated by the synthesis of a set of degenerate oligonucleotide sequences.

#### -PCR Mutagenesis

5 In PCR mutagenesis, reduced Taq polymerase fidelity can be used to introduce random mutations into a cloned fragment of DNA (Leung et al., 1989, *Technique* 1:11-15). This is a very powerful and relatively rapid method of introducing random mutations. The DNA region to be mutagenized can be amplified using the polymerase chain reaction (PCR) under conditions that reduce the fidelity of DNA synthesis by Taq DNA polymerase, e.g., by  
10 using a dGTP/dATP ratio of five and adding  $Mn^{2+}$  to the PCR reaction. The pool of amplified DNA fragments can be inserted into appropriate cloning vectors to provide random mutant libraries.

#### -Saturation Mutagenesis

Saturation mutagenesis allows for the rapid introduction of a large number of single  
15 base substitutions into cloned DNA fragments (Mayers et al., 1985, *Science* 229:242). This technique includes generation of mutations, e.g., by chemical treatment or irradiation of single-stranded DNA *in vitro*, and synthesis of a complimentary DNA strand. The mutation frequency can be modulated by modulating the severity of the treatment, and essentially all possible base substitutions can be obtained. Because this procedure does not involve a genetic  
20 selection for mutant fragments both neutral substitutions, as well as of a protein can be prepared by random mutagenesis of DNA which those that alter function, can be obtained. The distribution of point mutations is not biased toward conserved sequence elements.

#### -Degenerate Oligonucleotides

A library of homologs can also be generated from a set of degenerate oligonucleotide  
25 sequences. Chemical synthesis of degenerate sequences can be carried out in an automatic DNA synthesizer, and the synthetic genes then ligated into an appropriate expression vector. The synthesis of degenerate oligonucleotides is known in the art<sup>31</sup> Such techniques have been employed in the directed evolution of other proteins<sup>32</sup>.

Non-random or directed, mutagenesis techniques can be used to provide specific  
30 sequences or mutations in specific regions. These techniques can be used to create variants

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which include, e.g., deletions, insertions, or substitutions, of residues of the known amino acid sequence of a protein. The sites for mutation can be modified individually or in series, e.g., by (1) substituting first with conserved amino acids and then with more radical choices depending upon results achieved, (2) deleting the target residue, or (3) inserting residues of the same or a different class adjacent to the located site, or combinations of options 1-3.

#### -Alanine Scanning Mutagenesis

Alanine scanning mutagenesis is a useful method for identification of certain residues or regions of the desired protein that are preferred locations or domains for mutagenesis, Cunningham and Wells (*Science* 244:1081-1085, 1989) specifically incorporated by reference. In alanine scanning, a residue or group of target residues are identified (e.g., charged residues such as Arg, Asp, His, Lys, and Glu) and replaced by a neutral or negatively charged amino acid (most preferably alanine or polyalanine). Replacement of an amino acid can affect the interaction of the amino acids with the surrounding aqueous environment in or outside the cell. Those domains demonstrating functional sensitivity to the substitutions can then be refined by introducing further or other variants at or for the sites of substitution. Thus, while the site for introducing an amino acid sequence variation is predetermined, the nature of the mutation per se need not be predetermined. For example, to optimize the performance of a mutation at a given site, alanine scanning or random mutagenesis may be conducted at the target codon or region and the expressed desired protein subunit variants are screened for the optimal combination of desired activity.

#### -Oligonucleotide-Mediated Mutagenesis

Oligonucleotide-mediated mutagenesis is a useful method for preparing substitution, deletion, and insertion variants of DNA, see, e.g., Adelman et al., (*DNA* 2:183, 1983) incorporated herein by reference. Briefly, the desired DNA can be altered by hybridizing an oligonucleotide encoding a mutation to a DNA template, where the template is the single-stranded form of a plasmid or bacteriophage containing the unaltered or native DNA sequence of the desired protein. After hybridization, a DNA polymerase is used to synthesize an entire second complementary strand of the template that will thus incorporate the oligonucleotide primer, and will code for the selected alteration in the desired protein DNA. Generally, oligonucleotides of at least 25 nucleotides in length are used. An optimal oligonucleotide will have 12 to 15 nucleotides that are completely complementary to the template on either side of



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the nucleotide(s) coding for the mutation. This ensures that the oligonucleotide will hybridize properly to the single-stranded DNA template molecule. The oligonucleotides are readily synthesized using techniques known in the art such as that described by Crea et al. (*Proc. Natl. Acad. Sci. USA*, 75: 5765[1978]) incorporated herein by reference.

5           -Cassette Mutagenesis

Another method for preparing variants, cassette mutagenesis, is based on the technique described by Wells et al. (*Gene*, 34:315[1985]) incorporated herein by reference. The starting material can be a plasmid (or other vector) which includes the protein subunit DNA to be mutated. The codon(s) in the protein subunit DNA to be mutated are identified. There must  
10 be a unique restriction endonuclease site on each side of the identified mutation site(s). If no such restriction sites exist, they may be generated using the above-described oligonucleotide-mediated mutagenesis method to introduce them at appropriate locations in the desired protein subunit DNA. After the restriction sites have been introduced into the plasmid, the plasmid is cut at these sites to linearize it. A double-stranded oligonucleotide encoding the sequence of  
15 the DNA between the restriction sites but containing the desired mutation(s) is synthesized using standard procedures. The two strands are synthesized separately and then hybridized together using standard techniques. This double-stranded oligonucleotide is referred to as the cassette. This cassette is designed to have 3' and 5' ends that are comparable with the ends of the linearized plasmid, such that it can be directly ligated to the plasmid. This plasmid now  
20 contains the mutated desired protein subunit DNA sequence.

          -Combinatorial Mutagenesis

Combinatorial mutagenesis can also be used to generate mutants. E.g., the amino acid sequences for a group of homologs or other related proteins are aligned, preferably to promote the highest homology possible. All of the amino acids which appear at a given position of the  
25 aligned sequences can be selected to create a degenerate set of combinatorial sequences. The variegated library of variants is generated by combinatorial mutagenesis at the nucleic acid level, and is encoded by a variegated gene library. For example, a mixture of synthetic oligonucleotides can be enzymatically ligated into gene sequences such that the degenerate set of potential sequences are expressible as individual peptides, or alternatively, as a set of larger  
30 fusion proteins containing the set of degenerate sequences.

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Various techniques are known in the art for screening generated mutant gene products. Techniques for screening large gene libraries often include cloning the gene library into replicable expression vectors, transforming appropriate cells with the resulting library of vectors, and expressing the genes under conditions in which detection of a desired activity, e.g., in this case, binding to TRELL or its receptor, facilitates relatively easy isolation of the vector encoding the gene whose product was detected. Each of the techniques described below is amenable to high through-put analysis for screening large numbers of sequences created, e.g., by random mutagenesis techniques.

The invention also provides for reduction of the protein binding domains of the subject TRELL polypeptides or their receptors, to generate mimetics, e.g. peptide or non-peptide agents. The peptide mimetics are able to disrupt binding of a TRELL and its receptor. The critical residues of TRELL involved in molecular recognition of a receptor polypeptide or of a downstream intracellular protein, can be determined and used to generate TRELL or its receptor-derived peptidomimetics which competitively or noncompetitively inhibit binding of the TRELL with a receptor. (see, for example, "Peptide inhibitors of human papilloma virus protein binding to retinoblastoma gene protein" European patent applications EP-412,762A and EP-B31,080A), specifically incorporated herein by reference.

#### G. PHARMACEUTICAL COMPOSITIONS

By making available purified and recombinant-TRELL, the present invention provides assays which can be used to screen for drugs candidates which are either agonists or antagonists of the normal cellular function, in this case, of TRELL or its receptor. In one embodiment, the assay evaluates the ability of a compound to modulate binding between TRELL and its receptor. A variety of assay formats will suffice and, in light of the present inventions, will be comprehended by the skilled artisan.

In many drug screening programs which test libraries of compounds and natural extracts, high throughput assays are desirable in order to maximize the number of compounds surveyed in a given period of time. Assays which are performed in cell-free systems, such as may be derived with purified or semi-purified proteins, are often preferred as "primary" screens in that they can be generated to permit rapid development and relatively easy detection of an alteration in a molecular target which is mediated by a test compound.

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Moreover, the effects of cellular toxicity and/or bioavailability of the test compound can be generally ignored in the *in vitro* system, the assay instead being focused primarily on the effect of the drug on the molecular target as may be manifest in an alteration of binding affinity with other proteins or change in enzymatic properties of the molecular target.

5           Pharmaceutical compositions of the invention may comprise a therapeutically effective amount of TRELLE or TRELLE-receptor, or fragments or mimetics thereof, and, optionally may include pharmaceutically acceptable carriers. Accordingly, this invention provides methods for treatment of cancer, and methods of stimulating, or in certain instances, inhibiting the immune system, or parts thereof by administering a pharmaceutically effective amount of a  
10       compound of the invention or its pharmaceutically acceptable salts or derivatives. It should of course be understood that the compositions and methods of this invention can be used in combination with other therapies for various treatments.

          The compositions can be formulated for a variety of routes of administration, including systemic, topical or localized administration. For systemic administration, injection  
15       is preferred, including intramuscular, intravenous, intraperitoneal, and subcutaneous for injection, the compositions of the invention can be formulated in liquid solutions, preferably in physiologically compatible buffers such as Hank's solution or Ringer's solution. In addition, the compositions may be formulated in solid form and, optionally, redissolved or suspended immediately prior to use. Lyophilized forms are also included in the invention.

20           The compositions can be administered orally, or by transmucosal or transdermal means. For transmucosal or transdermal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are known in the art, and include, for example, for transmucosal administration, bile salts, fusidic acid derivatives, and detergents. Transmucosal administration may be through nasal sprays or using suppositories.  
25       For oral administration, the compositions are formulated into conventional oral administration forms such as capsules, tablets, and tonics. For topical administration, the compositions of the invention are formulated into ointments, salves, gels, or creams as known in the art.

          Preferably the compositions of the invention will be in the form of a unit dose and will  
30       be administered one or more times a day. The amount of active compound administered at one time or over the course of treatment will depend on many factors. For example, the age

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and size of the subject, the severity and course of the disease being treated, the manner and form of administration, and the judgments of the treating physician. However, an effective dose may be in the range of from about 0.005 to about 5 mg/kg/day, preferably about 0.05 to about 0.5 mg/kg/day. One skilled in the art will recognize that lower and higher doses may also be useful.

Gene constructs according to the invention can also be used as a part of a gene therapy protocol to deliver nucleic acids encoding either an agonistic or antagonistic form of a TRELL polypeptide.

Expression constructs of TRELL can be administered in any biologically effective carrier, e.g., any formulation or composition capable of effectively delivering the gene for TRELL to cells in vivo. Approaches include insertion of the gene in viral vectors which can transfect cells directly, or delivering plasmid DNA with the help of, for example, liposomes, or intracellular carriers, as well as direct injection of the gene construct. Viral vector transfer methods are preferred.

A pharmaceutical preparation of the gene therapy construct can consist essentially of the gene delivery system in an acceptable diluent, or can comprise a slow release matrix in which the gene delivery vehicle is imbedded. Alternatively, where the complete gene delivery system can be produced intact from recombinant cells, e.g. retroviral vectors, the pharmaceutical preparation can comprise one or more cells which produce the gene delivery system.

In addition to use in therapy, the oligomers of the invention may be used as diagnostic reagents to detect the presence or absence of the target DNA, RNA or amino acid sequences to which they specifically bind. In other aspects, the claimed invention may be used to evaluate a chemical entity for its ability to interact with, e.g., bind or physically associate with a TRELL polypeptide, or fragment thereof. The method includes contacting the chemical entity with the TRELL polypeptide, and evaluating the ability of the entity to interact with the TRELL. Additionally, the TRELL of the invention can be used in methods of evaluating naturally occurring ligands or receptors of TRELL, as well as to evaluate chemical entities which associate or bind with receptors of TRELL.

In certain aspects, the claimed invention features a method for evaluating a chemical entity for the ability to modulate the interaction between TRELL and its receptor. The

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method includes combining a TRELL receptor, and TRELL under conditions wherein the pair is capable of interacting, adding the chemical entity to be evaluated and detecting the formation or dissolution of complexes. These modulating agents may be further evaluated in vitro, e.g. by testing its activity in a cell free system, and then, optionally administering the compound to a cell or animal, and evaluating the effect.

#### H. EXAMPLES

##### 1. ISOLATION OF TRELL cDNAS

###### a) Cloning of murine TRELL

The cDNA coding for mTRELL was isolated by PCR from a cDNA library from mouse peritoneal macrophages. The amino acid sequence and the placement of the transmembrane region are typical of a membrane protein. The amino acid sequence of mTRELL is set forth in SEQ. ID. NO. 2, and the DNA sequence is set forth in SEQ. ID. NO. 1.

Macrophage cells were obtained from Balb/c mice by peritoneal lavage and cells that adhered to plastic within one hour were lysed and processed for RNA extraction. An antisense oligonucleotide primer 5'GTTCCAGGCCAGCCTGGG3' from a mouse erythropoietin sequence was synthesized. C.B. Shoemaker and L.D. Mistock, "Murine erythropoietin gene: cloning, expression and human gene homology", Mol. Cell. Biol., 6, 849 (1986), specifically incorporated herein by reference. This primer was used in a 5' RACE protocol following the recommendation of the manufacturer (5' RACE system from BRL) in association with the BRL-designed anchor primer. A first strand of cDNA was made from RNA from one hour adherent peritoneal macrophages. Amplification was done in a Perkin Elmer DNA thermal cycler with Taq DNA polymerase from Perkin Elmer. After a denaturation of 5 min. at 94°C, cycling conditions were as follows: 35 cycles at 94°C for 30 sec., 55°C for 30 sec. and 72°C for 3 min. An additional extension at 72°C was performed and then reactions were held at 4°C. Analysis of the PCR experiment on agarose gel revealed 2 amplified fragments of 650bp and 500bp. The 2 fragments were excised from the gel, inserted in pBS-T vectors and sequenced. The two inserts were different. They both had at each extremity the same erythropoietin gene specific oligonucleotide used to prime the PCR synthesis. Northern hybridizations with 32P labeled-random-primed fragments indicated that

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they hybridized to two different RNA, the 500bp fragment hybridizing to a 1.4 kb RNA in macrophages. <sup>32</sup>P-labeled-riboprobes in both directions were used in Northern hybridization to determine the orientation of the cDNA.

From the determined orientations and sequences, two internal primers for the 1.4Kb mRNA were derived. These were used in 3' and 5' RACE-PCR respectively. The 3'RACE experiment revealed a 750bp fragment which was inserted in a pBS-T vector and sequenced. It corresponds to the 3' end of the 1.4 Kb RNA since the sequence possess a polyA addition signal AATAAA just prior to the poly A tract. The 5'RACE did not reveal any band. The Clontech Marathon cDNA amplification kit was used to prepare a cDNA library from one hour adherent macrophage. A 1040bp PCR fragment, isolated by PCR with sense and antisense oligonucleotide primers from the determined cDNA sequence were used, and the universal primer from the kit. This resulted in the isolation of a fragment of a larger size than the original 1040bp fragment. The new fragment which was sequenced added 60bp to the 5'sequence (SEQ ID NO:1).

RNA were extracted from mouse thioglycolate induced peritoneal macrophages after 1 hour adherence. Hybridization was performed with <sup>32</sup>P-labeled mTRELL cDNA. Figure 3 depicts northern analysis of TRELL mRNA expression in mouse peritoneal macrophages and in different mouse tissues.

The first 21 amino acids delineate a hydrophobic, transmembrane domain. No identical sequences at the nucleotide or the amino acid levels were found in the available databases. Using the PROSITE program, and the 225 amino acid sequence it was determined that the sequence belonged to the TNF family of proteins. The protein also possessed the different domains described for LT- $\alpha$  and other members of this family (J. Browning et al., Lymphotoxin- $\alpha$ , a novel member of the TNF family that forms a heteromeric complex with lymphotoxin on the cell surface", *Cell*, 72, 847 (1993); C. F. Ware et al., "The ligands and receptors of the lymphotoxin system", in Pathways for cytolysis, G. M. Griffiths and J. Tschopp (Eds), Springer-Verlag, Berlin, Heidelberg, p175-218 (1995), each of which is specifically incorporated herein by reference). This sequence is unique. At the nucleotide or amino acid levels, weak identity or similarity were observed with the different members of the TNF family or with any sequences. Searching in EST data bases, 1 human sequence was clearly homologous to the murine sequence. The clone 154742,5' (GenBank accession no:

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R55379) from a breast library made by Soares, Washington University, has a 345 base pair sequence, 89% homologous to the murine TRELL. No human sequence in the available databases was found matching the available 5' DNA of mTRELL.

b) Cloning of Human TRELL

5 i) Generation of oligonucleotide probes and PCR primers.

The sequence of the human EST R55379 which has homology to mouse TRELL was used as a basis for synthesis of oligonucleotide primers. Two sense strand 20mer oligonucleotides:

LTB-065 5'-CCC TGC GCT GCC TGG AGG AA (NT 70-89 of R55379)

10 LTB-066 5'-TGA TGA GGG GAA GGC TGT CT (NT 14-33 of R55379) and one antisense 20mer oligonucleotide:

LTB-067 5'-AGA CCA GGG CCC CTC AGT GA (NT 251- 270 of R55379) were synthesized.

ii) Identification of mRNA and cDNA library source for cloning hTRELL.

15 PolyA+ mRNA from Human liver (cat#6510-1), spleen (cat#6542-1) and lymph node (cat# 6594-1) were purchased from Clontech. PolyA+ mRNA from Human cell lines THP-1, U937 and II-23 were generated at Biogen, Cambridge, MA. A Human tonsil cDNA library in Lambda gt10, and DNA from the Tonsil library were also prepared at Biogen.

RT-PCR was performed on the six RNA samples. Each cDNA reaction contained 1ug  
20 polyA+ mRNA, 50mM Tris pH 8.3, 75mM KCl, 3mM MgCl<sub>2</sub>, 10 mM DTT, 250 uM dNTP, 50ng random hexamer (50ng/ul) and 400 units SuperscriptII Reverse transcriptase (Gibco BRL cat#6542-1) in a final volume of 40 ul. The reaction was incubated at 20EC for 20 minutes, 42EC for 50 min., and 99EC for 5 min. For PCR, one-fifth of each cDNA reaction or 100-1000ng of the cDNA library DNA was used. Two PCR reactions for each sample  
25 were set up, one with primer pair LTB-065 and LTB-067 which yields a 201bp PCR product, and the second reaction with primer pair LTB-066 and LTB-067 which yields a 257bp product if the transcript is represented in the sample. PCR reactions were performed in 10mM Tris pH8.3, 50mM KCl, 1.5 mM MgCl<sub>2</sub>, 0.01% gelatin, 10% DMSO 100uM dNTP, 30pmole each primer and 5 units Amplitaq (Perkin Elmer cat#N801-0060). PCR was carried out in a

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Perkin Elmer Cetus DNA Thermal Cycler Model#480. Cycle conditions used were 95EC 1 minute, 60EC 1 minute, and 72EC 1 minute for 35 cycles.

The correct size products were obtained from liver, spleen, lymph node, THP-1 and tonsil, but not from U937 or II-23 mRNA. The 201bp PCR product generated from liver was purified for use as a probe for screening the cDNA library.

### iii) cDNA Library Screening

Having demonstrated by PCR that the tonsil library contained TRELL, one million plaque forming units(PFU) from the Lambda gt10 Human tonsil cDNA library were plated at a density of  $1 \times 10^5$  PFU / Nunc<sup>TM</sup> plate. Duplicate lifts were made onto 20x20cm Schleicher and Scheull BA-S 85 Optitran<sup>TM</sup> filters. The 201bp PCR product was P<sup>32</sup> labeled by random priming (Feinberg and Vogelstein, Anal. Biochem 137:266-267,1984 specifically incorporated herein by reference). The filters were hybridized overnight at 65EC in 400 ml plaque screen buffer (50mM Tris pH7.5, 1M NaCl, 0.1% sodium pyrophosphate, 0.2% PVP and 0.2% Ficoll) containing 10% dextran sulphate, 100ug/ml tRNA and  $6 \times 10^5$  CPM/ml probe. They were washed twice with plaque screen buffer and twice with 2X SSC, 0.1% SDS at 65C and exposed to film at -70C with an intensifying screen for 40 hours.

Duplicate positives were cored from the master plates into SM (100mM NaCl, 10mM MgSO<sub>4</sub>, 50mM Tris pH 7.5) plus gelatin. 12 of the positives were plaque purified. Lambda miniprep DNA from 12 purified candidates was digested with NotI, electrophoresed on 1% agarose gel, Southern blotted and hybridized with the 201 bp probe. The clones with the largest inserts (approximately 2 kb) which hybridized to the probe were selected for large scale DNA purification and DNA sequencing. The inserts from each of these clones was subcloned into the NotI site of pBluescript SK+ (Stratagene #212205). DNA sequence was obtained from the Lambda DNA and the plasmid DNA. Clone F1a which has an cDNA insert of 2006bp appeared to have an intron in the 5' end of the coding region and did not contain a complete open reading frame. Clone A2a, also called PB133 contained a cDNA insert of 1936bp. This clone contained 543bp 5' untranslated region, an open reading frame of 852bp and 3' untranslated region but no polyadenylation signal or polyA tail.

The nucleotide sequence encoding the open reading frame of the hTRELL cDNA clone A2a is set forth in SEQ ID. NO. 3. The deduced 284 amino acid sequence is set forth in

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SEQ ID. NO. 4. The second methionine at position 36 may be a more likely translation start site, since this site more closely meets the requirements for a start as defined by Kozak.

Using the sequences identified, the sequences of cDNAs coding on TRELL were determined. From the DNA sequences described above (i.e. SEQ. ID. NO. 3), we deduced the amino acid sequences of TRELL (SEQ. ID. NO. 4). It should be clear that given the current state of the protein-engineering art, an artisan could make purposeful alterations, insertions or deletions in these amino acid sequences and obtain a variety of molecules having substantially the same biological or immunological activities as those of the molecules we have described herein.

iv. Northern Analysis of human TRELL expression

A 440 bp PpuM1/BstX1 fragment of the human cDNA clone 2a was <sup>32</sup>P labeled by random priming and used to probe commercial northern blots containing RNA from various human tissues. Northern analysis showed that the hTRELL fragment hybridized to a single mRNA species about 1.4 to 1.6 kb in length. Human TRELL is expressed in most organs of the immune system, i.e. spleen, peripheral blood lymphocytes (pbl), lymph nodes, appendix but was relatively low in thymus, fetal liver (source of progenitor lymphocytes) and bone marrow (Figure 4). Therefore, organs of the secondary immune system primarily express TRELL. Expression was also detected in the ovary, prostate, small intestine, colon, heart, brain, placenta, lung, liver, skeletal muscle, kidney and pancreas. Expression was relatively low in testis, liver, kidney and thymus. This pattern indicates widespread expression closely resembling that of the TRAIL ligand except that TRAIL is poorly expressed in heart and brain.

c) Isolation of a receptor binding to the TRELL Ligand

Ligands of the TNF family can be used to identify and clone receptors. With the described TRELL sequence, one could fuse the 5' end of the extracellular domain of TRELL ligand which constitutes the receptor binding sequence to a marker or tagging sequence and then add a leader sequence that will force secretion of the ligand in any of a number of expression systems. One example of this technology is described by Browning et al., (1996) (JBC 271, 8618-8626) where the LT- $\beta$  ligand was secreted in such a form. The VCAM leader

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sequence was coupled to a short myc peptide tag followed by the extracellular domain of the LT- $\beta$ . The VCAM sequence is used to force secretion of the normally membrane bound LT- $\beta$  molecule. The secreted protein retains a myc tag on the N-terminus which does not impair the ability to bind to a receptor. Such a secreted protein can be expressed in either transiently transfected Cos cells or a similar system, e.g., EBNA derived vectors, insect cell/baculovirus, picchia etc. The unpurified cell supernatant can be used as a source of the tagged ligand.

Cells expressing the receptor can be identified by exposing them to the tagged ligand. Cells with bound ligand are identified in a FACS experiment by labelling the myc tag with an anti-myc peptide antibody (9E10) followed by phycoerythrin (or a similar label) labelled anti-mouse immunoglobulin. FACS positive cells can be readily identified and would serve as a source of RNA encoding for the receptor. An expression library would then be prepared from this RNA via standard techniques and separated into pools. Pools of clones would be transfected into a suitable host cell and binding of the tagged ligand to receptor positive transfected cells determined via microscopic examination, following labelling of bound myc peptide tag with an enzyme labelled anti-mouse Ig reagent, i.e. galactosidase, alkaline phosphatase or luciferase labelled antibody. Once a positive pool has been identified, the pool size would be reduced until the receptor encoding cDNA is identified. This procedure could be carried out with either the mouse or human TRELL' as one may more readily lead to a receptor.

## 2. Cells and Reagents

All cells were obtained from the American Type Culture Collection (ATCC, Rockville, MD) except for WEHI 164 clone 13 which was obtained from Dr. Kawashima (Geneva Biomedical Research Institute, Geneva, Switzerland). The HT29 subclone (HT29-14) was previously described (Browning et al., 1996) and the TNF sensitive ME180 subclone was obtained from Dr. Carl Ware. The II-23 T cell hybridoma has been described (Browning et al., 1991). Balb/c mice were injected intraperitoneally 3 days before sacrifice with 1.5 ml of thioglycolate broth (Difco Lab., MI). Cells were taken from the peritoneal cavity and cultured at  $10^6$  cells/ml for 1 hr in DMEM (Gibco Lab). Non adherent cells were washed off the plates and the adherent cells, almost exclusively macrophages, were lysed in Tri-Reagent (Molecular Research Center Inc.) and processed for RNA extraction.

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Recombinant human TNF, LTa, LTa1/b2, antibodies to these proteins and the receptor-Ig fusion proteins have been described previously (Browning et al., 1995). The anti-CD40L antibody 5C8 has been described. A polyclonal anti-hTRELL serum was prepared by intra lymph node injection of pure recombinant hTRELL in CFA as described previously (Browning and Ribolini, 1989). After 2 months, an anti-hTRELL response was observed and immunoglobulin was purified using Protein A-Sepharose.

### Mouse TRELL Cloning

The antisense oligonucleotide primer 5'GTTCCAGGCCAGCCTGGG3' from the mouse erythropoietin sequence was used it in a 5' RACE protocol following the recommendation of the manufacturer (5' RACE system from BRL) in association with the BRL-designed anchor primer. First strand cDNA was made from RNA from 1 hr. adherent peritoneal macrophages. Amplification was done in a Perkin Elmer DNA thermal cycler with Taq DNA polymerase. After a denaturation of 5min. at 94/ C, cycling conditions were as follows: 35 cycles of 30 sec. at 94/ C, 30 sec at 55/ C and 3 min at 72/ C followed by a terminal additional extension at 72/ C. Analysis of the PCR experiment on agarose gel revealed 2 amplified fragments of 650 bp and 500 bp. The 2 fragments were excised from the gel, inserted in pBS-T vectors and sequenced. Northern hybridizations with <sup>32</sup>P labeled-random-primed fragments indicated that the 500 bp fragment hybridizing to a 1.4 kb RNA in macrophages. To determine the orientation of the cDNA, 32P-labeled-riboprobes in both direction were used in Northern hybridization. From the determined orientations and sequences, we derived two internal primers for the 1.4 kb mRNA: 5' TCAGGTGCACTTTGATGAGG 3' and 5'CTGTCAGCTCCTCCTGAG 3' which were used in 3' and 5' RACE-PCR respectively. The 3' RACE experiment revealed a 750bp fragment which was inserted in a pBS-T vector and sequenced. It corresponded to the 3' end of the 1.4 kb RNA since the sequence possessed a polyA addition signal just prior to the poly A tract. The 5' RACE did not revealed any band. The Clontech Marathon cDNA amplification kit was used to prepare a cDNA library from 1 hr. adherent macrophages. PCR used a 1040 bp PCR fragment isolated with sense and antisense oligonucleotide primers from the determined cDNA sequence (5'AGCAGGAGCCTTCTCAGGAG 3' and

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5'GATCCAGGGAGGAGCTTGTCC 3') and the universal primer from the kit. This resulted in the isolation of a fragment 60 bp longer on the 5' end than the original 1040 bp fragment.

### Human TRELL Cloning

A search of the EST data base showed 1 human clone that was clearly homologous to the murine sequence. The clone 154742 (Genbank accession no: R55379) has a 345 bp sequence 89% homologous to the murine cDNA. Two primers derived from the EST (5' CCCTGCGCTGCCTGGAGGAA 3': and 5' AGACCAGGGCCCCTCAGTGA 3') were used to screen by RT-PCR different tissues and libraries for the presence of hTRELL transcripts. Correct size products were obtained from liver, spleen, lymph node, THP-1 and tonsil, but not from U937 mRNA. The 201 bp product was cloned and used to screen a lambda gt10 human tonsil cDNA library.  $10^6$  plaque forming units were plated at  $10^5$  PFU/plate. Duplicate lifts were made onto 20x20 cm nitocellulose filters and hybridized with a probe prepared by random-priming. The filters were hybridized overnight at 65/ C in plaque screen buffer (50 mM Tris pH7.5, 1 M NaCl, 0.1% sodium pyrophosphate, 0.2% polyvinylpyrrolidone and 0.2% Ficoll) containing 10% dextran sulphate, 100 mg/ml tRNA and  $6 \times 10^5$  cpm/ml of probe. They were washed twice with plaque screen buffer and twice with 2XSSC, 0.1% SDS at 65/ C. Lambda miniprep DNAs were prepared from positive colonies and the clones with the largest inserts were selected for large scale DNA purification and DNA sequencing. The inserts were subcloned into the NotI site of pBlueScript SK+.

\_\_\_ human ESTs were found encoding parts of the \_\_\_\_\_

### RNA Analysis

Either a 0.45 kb PpuM1/BstX1 or a 1.25 NarI/NotI fragment of the hTRELL cDNA was labeled by random priming and used to probe human and mouse tissue northern blots purchased from Clontech. Mouse tissues and cells were RNA-extracted with TRI-reagent. Northern analysis were done essentially as already described (Chicheportiche and Vassalli, 1994) with 4 ug of total RNA and  $32P$  labeled random primed mTRELL cDNA.

### Chromosomal assignment

A panel of DNA from monochromosomal cell hybrids (HGMP Resource centre, Hinxton, Cambridge, UK) was used to amplify by PCR a 340bp fragment with primers chosen

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in 3' untranslated region that are not homologous to the murine sequence (5' AGTCGTCCCAGGCTGCCGGCT 3' and 5' CCTGAAGTGGGGTCTTCTGGA 3'). Amplification was done for 40 cycles, 30 sec at 94/ C, 90 sec at 65/ C and 90 sec at 72/ C. Detection was carried out on ethidium bromide stained agarose gel.

## 5 Expression of Recombinant hTRELL Protein

A soluble expression construct combining the VCAM leader sequence, the myc peptide tag and the extracellular domain of hTRELL similar to that described for lymphotoxin-b (ref) was prepared in a manner similar to that described for LTb (Browning et al., 1996). The following DNA fragments were isolated, a NotI/blunt fragment encoding the  
10 VCAM leader and a pair of oligonucleotides encoding the myc tag (5' blunt, 3' PpuM1 site) which have been described, a 0.45 kb PpuM1/BstX1 fragment of TRELL and a 0.65 BstX1/NotI fragment of TRELL. The four fragments were ligated into a NotI/phosphatased pBluescript vector. The NotI insert from this vector was transferred into the pFastBac1 vector (GibcoBRL) and used to generate recombinant baculovirus. Soluble TRELL was  
15 prepared by infecting HiFive™ insect cells at a MOI of 10 and the medium was harvested after 2 days. The following items were added to the media : HEPES buffer to a final concentration of 25 mM, pH 7.4, 1 mM AEBSF (Pierce) and 1 mg/ml pepstatin. The media was filtered and concentrated ten fold by ultrafiltration over a Amicon 10 kDa cutoff filter. Concentrated TRELL containing medium was directly loaded onto a SP sepharose Fast Flow  
20 column and washed with 25 mM HEPES buffer pH 7.0 containing 0.4 M NaCl. TRELL was eluted with the same buffer with 0.6 M NaCl. Purified TRELL was subjected to sizing analysis on a \_\_\_\_\_.

## Analysis of Secretion

Vectors for EBNA based expression were constructed using the vector CH269 which  
25 is a modified version of the pEBVHis ABC (Invitrogen) wherein the EBNA gene and the histidine tag were removed. A 0.71 kb fragment of hTNF in the pFastBac vector was provided by Dr. P. Pescamento and A. Goldfeld. The SnaBI/XhoI insert was ligated into the PvuII/XhoI site of CH269. A genomic TNF insert containing the \_1-12 cleavage site deletion was a gift from Dr. G. Kollias and was inserted into the CH269 vector by A. Goldfeld. A 1.8  
30 kb NotI insert of hTRELL clone A2A, the 0.98 kb NotI fragment containing the hCD40L

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cDNA provided by Dr. E. Garber and a 1.46 kb NotI insert containing hLTa (Browning et al., 1995) were ligated into the NotI site of CH269. A 0.81 kb HindIII insert containing the hLTb coding region with a modified start site (Browning et al., 1995) was ligated into the HindIII site of CH269. EBNA-293 cells were transfected with the various CH269 vectors along with the GFP vector using lipofectamine and either removed with PBS with 5 mM EDTA for FACS analysis or after 2 days the cells were subjected to metabolic labelling. Both procedures utilized the following antibodies, hTRELL a rabbit polyclonal Ig fraction, hTNF the mAb 104c, hLTa the mAb AG9, LTa1/b2 the mAb B9 and CD40L the mAb 5C8. FACS analysis was carried out in RPMI medium containing 10% FBS and 50 ug/ml heat aggregated human IgG with the antibodies at 5 ug/ml. Phycoerythrin labelled anti-mouse or rabbit IgG (Jackson ImmunoResearch) was used to detect antibody binding. GFP bright transfected cells were live gated. For immunoprecipitation, cells 2 days after transfection were washed with PBS and transferred into met/cys free MEM containing 200 uCi/ml TranSlabel (ICN). After 24 h the supernatants were harvested and subjected to immunoprecipitation as described (Browning et al., 1995).

#### Cytotoxicity Assays:

Cell growth assays were carried out as previously described (Browning and Ribolini, 1989). For microscopy, HT29-14 cells were seeded into 12 well plates at a density of 200,000 cells/well and grown for 2 days. Human TRELL, TNF, lymphotoxin-a1b2 (Browning et al., 1996) or anti-fas (CH11, Kamaya) were added along with 80 units/ml of human interferon-g. After 26 h, the medium was removed which after cytokine or anti-fas treatment included many dead cells that had detached from the plastic. The remaining cells were fixed with 80% ethanol and washed into PBS containing 1 mg/ml Hoescht dye. After 2 min the dye was removed, cells were washed into PBS and examined by fluorescence microscopy.

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**Table II: Human TRELL Binding Sites and Cytotoxic Effects on Various Cell Lines**

	<u>Cell Line</u>	<u>Type</u>	<u>TRELL Binding</u>	<u>Cytotoxicity<sup>a</sup></u>
5	<u>Hematopoietic</u>			
	Jurkat	T lymphoma	-	-
	SKW 6.4	EBV B cell		-
	Namalwa	Burkitt lymphoma	-	-
10	K562	promyelocytic	+	-
	THP-1	monocytic leukemia	++	-
	<u>Nonhematopoietic</u>			
	HT29	colon adenocarcinoma	+	++ <sup>b</sup>
15	ME-180	cervical carcinoma		-
	Hela	cervical carcinoma		- <sup>d</sup>
	MCF-7	breast adenocarcinoma		+/-
	293	embryonic kidney cells	+	nd
20	Cos	kidney fibroblasts	+	nd

<sup>a</sup>3-5 day proliferation assay in the presence and absence of human interferon-g.<sup>b</sup>Cytotoxicity was only observed in the presence of interferon-g.<sup>c</sup>ND, not determined.<sup>d</sup>Morphology changes

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**Table III: Grouping of Various TNF Family Members by Cytotoxicity Patterns**

<b>Group</b>	<b>Receptor Activation</b>
5	Potent inducers of apoptosis in many cell types
Weak inducers only in limited cell types	TNF, Fas, TRAIL-R <sup>a</sup> , DR-3
10	Cannot induce cell death, anti-proliferative in some settings
LTb-R, TRELL-R <sup>a</sup> , CD30	CD27, CD40, OX-40

<sup>a</sup>These receptors have not yet been identified.



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## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

- (i) APPLICANT: Chicheportiche, Yves  
Browning, Jeffrey L.
- (ii) TITLE OF INVENTION: A TUMOR NECROSIS FACTOR RELATED LIGAND
- (iii) NUMBER OF SEQUENCES: 4
- (iv) CORRESPONDENCE ADDRESS:
  - (A) ADDRESSEE: BIOGEN, INC.
  - (B) STREET: 14 CAMBRIDGE CENTER
  - (C) CITY: CAMBRIDGE
  - (D) STATE: MA
  - (E) COUNTRY: US
  - (F) ZIP: 02142
- (v) COMPUTER READABLE FORM:
  - (A) MEDIUM TYPE: Floppy disk
  - (B) COMPUTER: IBM PC compatible
  - (C) OPERATING SYSTEM: PC-DOS/MS-DOS
  - (D) SOFTWARE: PatentIn Release #1.0, Version #1.30
- (vi) CURRENT APPLICATION DATA:
  - (A) APPLICATION NUMBER: not yet assigned
  - (B) FILING DATE: 07-May-1997
  - (C) CLASSIFICATION:
- (viii) ATTORNEY/AGENT INFORMATION:
  - (A) NAME: FLYNN, KERRY A.
  - (B) REGISTRATION NUMBER: 33,693
  - (C) REFERENCE/DOCKET NUMBER: A003 PCT
- (ix) TELECOMMUNICATION INFORMATION:
  - (A) TELEPHONE: (617) 679-3583
  - (B) TELEFAX: (617) 679-2838

## (2) INFORMATION FOR SEQ ID NO:1:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 1168 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: double
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: cDNA

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(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM: TNF family related protein

(ix) FEATURE:

(A) NAME/KEY: CDS

(B) LOCATION: 2..676

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

G GTG CTG AGC CTG GGC CTG GCG CTG GCC TGC CTT GGC CTC CTG CTG	46
Val Leu Ser Leu Gly Leu Ala Leu Ala Cys Leu Gly Leu Leu Leu	
1 5 10 15	
GTC GTG GTC AGC CTG GGG AGC TGG GCA ACG CTG TCT GCC CAG GAG CCT	94
Val Val Val Ser Leu Gly Ser Trp Ala Thr Leu Ser Ala Gln Glu Pro	
20 25 30	
TCT CAG GAG GAG CTG ACA GCA GAG GAC CGC CGG GAG CCC CCT GAA CTG	142
Ser Gln Glu Glu Leu Thr Ala Glu Asp Arg Arg Glu Pro Pro Glu Leu	
35 40 45	
AAT CCC CAG ACA GAG GAA AGC CAG GAT GTG GTA CCT TTC TTG GAA CAA	190
Asn Pro Gln Thr Glu Glu Ser Gln Asp Val Val Pro Phe Leu Glu Gln	
50 55 60	
CTA GTC CGG CCT CGA AGA AGT GCT CCT AAA GGC CGG AAG GCG CGG CCT	238
Leu Val Arg Pro Arg Arg Ser Ala Pro Lys Gly Arg Lys Ala Arg Pro	
65 70 75	
CGC CGA GCT ATT GCA GCC CAT TAT GAG GTT CAT CCT CGG CCA GGA CAG	286
Arg Arg Ala Ile Ala Ala His Tyr Glu Val His Pro Arg Pro Gly Gln	
80 85 90 95	
GAT GGA GCA CAA GCA GGT GTG GAT GGG ACA GTG AGT GGC TGG GAA GAG	334
Asp Gly Ala Gln Ala Gly Val Asp Gly Thr Val Ser Gly Trp Glu Glu	
100 105 110	
ACC AAA ATC AAC AGC TCC AGC CCT CTG CGC TAC GAC CGC CAG ATT GGG	382
Thr Lys Ile Asn Ser Ser Ser Pro Leu Arg Tyr Asp Arg Gln Ile Gly	
115 120 125	
GAA TTT ACA GTC ATC AGG GCT GGG CTC TAC TAC CTG TAC TGT CAG GTG	430
Glu Phe Thr Val Ile Arg Ala Gly Leu Tyr Tyr Leu Tyr Cys Gln Val	
130 135 140	

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CAC TTT GAT GAG GGA AAG GCT GTC TAC CTG AAG CTG GAC TTG CTG GTG His Phe Asp Glu Gly Lys Ala Val Tyr Leu Lys Leu Asp Leu Leu Val 145 150 155	478
AAC GGT GTG CTG GCC CTG CGC TGC CTG GAA GAA TTC TCA GCC ACA GCA Asn Gly Val Leu Ala Leu Arg Cys Leu Glu Glu Phe Ser Ala Thr Ala 160 165 170 175	526
GCA AGC TCT CCT GGG CCC CAG CTC CGT TTG TGC CAG GTG TCT GGG CTG Ala Ser Ser Pro Gly Pro Gln Leu Arg Leu Cys Gln Val Ser Gly Leu 180 185 190	574
TTG CCG CTG CGG CCA GGG TCT TCC CTT CGG ATC CGC ACC CTC CCC TGG Leu Pro Leu Arg Pro Gly Ser Ser Leu Arg Ile Arg Thr Leu Pro Trp 195 200 205	622
GCT CAT CTT AAG GCT GCC CCC TTC CTA ACC TAC TTT GGA CTC TTT CAA Ala His Leu Lys Ala Ala Pro Phe Leu Thr Tyr Phe Gly Leu Phe Gln 210 215 220	670
GTT CAC TGAGGGGCCT TGCTCTCCCA GATTCCTTAA ACTTTCCTG GCTCCAGGAG Val His 225	726
CATCACCACA CCTCCCTACC CCACCCCCAC TCCTCCACCC CCTCGCTGCT CCTTGGTCCA	786
GTCCTGTCTC TCCTCAAAGG CAGCCAGAGC TTGTTACAT GTTTCATT CACAGACGTA	846
TCCTTGCTCT TCTTAACATC CCATCCCACC ACAACTATCC ACCTCACTAG CTCCCAAAGC	906
CCCTACTTAT CCCTGACTCC CCCACCCACT CACCCGACCA CGTGTTTATT GACTTTGTGC	966
ACCAGGCACT GAGATGGGCT GGACCTGGTG GCAGGAAGCC AGAGAACCTG GGA CTAGGCC	1026
AGAAGTTCCC AACTGTGAGG GGGAAGAGCT GGGGACAAGC TCCTCCCTGG ATCCCTGTGG	1086
ATTTTGAAAA GATACTATTT TTATTATTAT TGTGACAAAA TGTTAAATGG ATATTAAAGA	1146
GAATAAATCA TGATTTCTCT TC	1168

## (2) INFORMATION FOR SEQ ID NO:2:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 225 amino acids
- (B) TYPE: amino acid
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

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Val Leu Ser Leu Gly Leu Ala Leu Ala Cys Leu Gly Leu Leu Leu Val  
 1 5 10 15  
 Val Val Ser Leu Gly Ser Trp Ala Thr Leu Ser Ala Gln Glu Pro Ser  
 20 25 30  
 Gln Glu Glu Leu Thr Ala Glu Asp Arg Arg Glu Pro Pro Glu Leu Asn  
 35 40 45  
 Pro Gln Thr Glu Glu Ser Gln Asp Val Val Pro Phe Leu Glu Gln Leu  
 50 55 60  
 Val Arg Pro Arg Arg Ser Ala Pro Lys Gly Arg Lys Ala Arg Pro Arg  
 65 70 75 80  
 Arg Ala Ile Ala Ala His Tyr Glu Val His Pro Arg Pro Gly Gln Asp  
 85 90 95  
 Gly Ala Gln Ala Gly Val Asp Gly Thr Val Ser Gly Trp Glu Glu Thr  
 100 105 110  
 Lys Ile Asn Ser Ser Ser Pro Leu Arg Tyr Asp Arg Gln Ile Gly Glu  
 115 120 125  
 Phe Thr Val Ile Arg Ala Gly Leu Tyr Tyr Leu Tyr Cys Gln Val His  
 130 135 140  
 Phe Asp Glu Gly Lys Ala Val Tyr Leu Lys Leu Asp Leu Leu Val Asn  
 145 150 155 160  
 Gly Val Leu Ala Leu Arg Cys Leu Glu Glu Phe Ser Ala Thr Ala Ala  
 165 170 175  
 Ser Ser Pro Gly Pro Gln Leu Arg Leu Cys Gln Val Ser Gly Leu Leu  
 180 185 190  
 Pro Leu Arg Pro Gly Ser Ser Leu Arg Ile Arg Thr Leu Pro Trp Ala  
 195 200 205  
 His Leu Lys Ala Ala Pro Phe Leu Thr Tyr Phe Gly Leu Phe Gln Val  
 210 215 220  
 His  
 225

(2) INFORMATION FOR SEQ ID NO:3:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 1373 base pairs
  - (B) TYPE: nucleic acid

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(C) STRANDEDNESS: double

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

(A) ORGANISM: TNF family related protein

(ix) FEATURE:

(A) NAME/KEY: CDS

(B) LOCATION: 1..852

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

ATG TCA TTG TTA GAC TTT GAA ATT TCC GCC CGC CGG CTC CCC CTC CCC	48
Met Ser Leu Leu Asp Phe Glu Ile Ser Ala Arg Arg Leu Pro Leu Pro	
1 5 10 15	
CGA TCC CTC GGG TCC CGG GAT GGG GGG GCG GTG AGG CAG GCA CAG CCC	96
Arg Ser Leu Gly Ser Arg Asp Gly Gly Ala Val Arg Gln Ala Gln Pro	
20 25 30	
CCC GCC CCC ATG GCC GCC CGT CGG AGC CAG AGG CGG AGG GGG CGC CGG	144
Pro Ala Pro Met Ala Ala Arg Arg Ser Gln Arg Arg Arg Gly Arg Arg	
35 40 45	
GGG GAG CCG GGC ACC GCC CTG CTG GTC CCG CTC GCG CTG GGC CTG GGC	192
Gly Glu Pro Gly Thr Ala Leu Leu Val Pro Leu Ala Leu Gly Leu Gly	
50 55 60	
CTG GCG CTG GCC TGC CTC GGC CTC CTG CTG GCC GTG GTC AGT TTG GGG	240
Leu Ala Leu Ala Cys Leu Gly Leu Leu Leu Ala Val Val Ser Leu Gly	
65 70 75 80	
AGC CGG GCA TCG CTG TCC GCC CAG GAG CCT GCC CAG GAG GAG CTG GTG	288
Ser Arg Ala Ser Leu Ser Ala Gln Glu Pro Ala Gln Glu Glu Leu Val	
85 90 95	
GCA GAG GAG GAC CAG GAC CCG TCG GAA CTG AAT CCC CAG ACA GAA GAA	336
Ala Glu Glu Asp Gln Asp Pro Ser Glu Leu Asn Pro Gln Thr Glu Glu	
100 105 110	
AGC CAG GAT CCT GCG CCT TTC CTG AAC CGA CTA GTT CGG CCT CGC AGA	384
Ser Gln Asp Pro Ala Pro Phe Leu Asn Arg Leu Val Arg Pro Arg Arg	
115 120 125	

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AGT GCA CCT AAA GGC CGG AAA ACA CGG GCT CGA AGA GCG ATC GCA GCC	432
Ser Ala Pro Lys Gly Arg Lys Thr Arg Ala Arg Arg Ala Ile Ala Ala	
130 135 140	
CAT TAT GAA GTT CAT CCA CGA CCT GGA CAG GAC GGA GCG CAG GCA GGT	480
His Tyr Glu Val His Pro Arg Pro Gly Gln Asp Gly Ala Gln Ala Gly	
145 150 155 160	
GTG GAC GGG ACA GTG AGT GGC TGG GAG GAA GCC AGA ATC AAC AGC TCC	528
Val Asp Gly Thr Val Ser Gly Trp Glu Glu Ala Arg Ile Asn Ser Ser	
165 170 175	
AGC CCT CTG CGC TAC AAC CGC CAG ATC GGG GAG TTT ATA GTC ACC CGG	576
Ser Pro Leu Arg Tyr Asn Arg Gln Ile Gly Glu Phe Ile Val Thr Arg	
180 185 190	
GCT GGG CTC TAC TAC CTG TAC TGT CAG GTG CAC TTT GAT GAG GGG AAG	624
Ala Gly Leu Tyr Tyr Leu Tyr Cys Gln Val His Phe Asp Glu Gly Lys	
195 200 205	
GCT GTC TAC CTG AAG CTG GAC TTG CTG GTG GAT GGT GTG CTG GCC CTG	672
Ala Val Tyr Leu Lys Leu Asp Leu Leu Val Asp Gly Val Leu Ala Leu	
210 215 220	
CGC TGC CTG GAG GAA TTC TCA GCC ACT GCG GCC AGT TCC CTC GGG CCC	720
Arg Cys Leu Glu Glu Phe Ser Ala Thr Ala Ala Ser Ser Leu Gly Pro	
225 230 235 240	
CAG CTC CGC CTC TGC CAG GTG TCT GGG CTG TTG GCC CTG CGG CCA GGG	768
Gln Leu Arg Leu Cys Gln Val Ser Gly Leu Leu Ala Leu Arg Pro Gly	
245 250 255	
TCC TCC CTG CGG ATC CGC ACC CTC CCC TGG GCC CAT CTC AAG GCT GCC	816
Ser Ser Leu Arg Ile Arg Thr Leu Pro Trp Ala His Leu Lys Ala Ala	
260 265 270	
CCC TTC CTC ACC TAC TTC GGA CTC TTC CAG GTT CAC TGAGGGGCCC	862
Pro Phe Leu Thr Tyr Phe Gly Leu Phe Gln Val His	
275 280	
TGGTCTCCCC ACAGTCGTCC CAGGCTGCCG GCTCCCCTCG ACAGCTCTCT GGGCACCCGG	922
TCCCCCTCTGC CCCACCCTCA GCCGCTCTTT GCTCCAGACC TGCCCCCTCCC TCTAGAGGCT	982
GCCTGGGCCT GTTCACGTGT TTTCCATCCC ACATAAATAC AGTATTCCCA CTCTTATCTT	1042
ACAACTCCCC CACCGCCAC TCTCCACCTC ACTAGCTCCC CAATCCCTGA CCCTTTGAGG	1102
CCCCCAGTGA TCTCGACTCC CCCCTGGCCA CAGACCCCCA GGGCATTGTG TTCACTGTAC	1162
TCTGTGGGCA AGGATGGGTC CAGAAGACCC CACTTCAGGC ACTAAGAGGG GCTGGACCTG	1222

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GCGGCAGGAA GCCAAAGAGA CTGGGCCTAG GCCAGGAGTT CCCAAATGTG AGGGGCGAGA 1282  
 AACAAAGACAA GCTCCTCCCT TGAGAATTCC CTGTGGATTT TAAAAACAGA TATTATTTTT 1342  
 ATTATTATTG TGACAAAATG TTGATAAATG G 1373

## (2) INFORMATION FOR SEQ ID NO:4:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 284 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Met Ser Leu Leu Asp Phe Glu Ile Ser Ala Arg Arg Leu Pro Leu Pro  
 1 5 10 15  
 Arg Ser Leu Gly Ser Arg Asp Gly Gly Ala Val Arg Gln Ala Gln Pro  
 20 25 30  
 Pro Ala Pro Met Ala Ala Arg Arg Ser Gln Arg Arg Arg Gly Arg Arg  
 35 40 45  
 Gly Glu Pro Gly Thr Ala Leu Leu Val Pro Leu Ala Leu Gly Leu Gly  
 50 55 60  
 Leu Ala Leu Ala Cys Leu Gly Leu Leu Leu Ala Val Val Ser Leu Gly  
 65 70 75 80  
 Ser Arg Ala Ser Leu Ser Ala Gln Glu Pro Ala Gln Glu Glu Leu Val  
 85 90 95  
 Ala Glu Glu Asp Gln Asp Pro Ser Glu Leu Asn Pro Gln Thr Glu Glu  
 100 105 110  
 Ser Gln Asp Pro Ala Pro Phe Leu Asn Arg Leu Val Arg Pro Arg Arg  
 115 120 125  
 Ser Ala Pro Lys Gly Arg Lys Thr Arg Ala Arg Arg Ala Ile Ala Ala  
 130 135 140  
 His Tyr Glu Val His Pro Arg Pro Gly Gln Asp Gly Ala Gln Ala Gly  
 145 150 155 160  
 Val Asp Gly Thr Val Ser Gly Trp Glu Glu Ala Arg Ile Asn Ser Ser  
 165 170 175

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Ser Pro Leu Arg Tyr Asn Arg Gln Ile Gly Glu Phe Ile Val Thr Arg  
180 185 190

Ala Gly Leu Tyr Tyr Leu Tyr Cys Gln Val His Phe Asp Glu Gly Lys  
195 200 205

Ala Val Tyr Leu Lys Leu Asp Leu Leu Val Asp Gly Val Leu Ala Leu  
210 215 220

Arg Cys Leu Glu Glu Phe Ser Ala Thr Ala Ala Ser Ser Leu Gly Pro  
225 230 235 240

Gln Leu Arg Leu Cys Gln Val Ser Gly Leu Leu Ala Leu Arg Pro Gly  
245 250 255

Ser Ser Leu Arg Ile Arg Thr Leu Pro Trp Ala His Leu Lys Ala Ala  
260 265 270

Pro Phe Leu Thr Tyr Phe Gly Leu Phe Gln Val His  
275 280

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I claim:

1. A DNA sequence encoding TRELL or a fragment thereof.
2. A DNA sequence encoding TRELL, said sequence consisting essentially of SEQ. ID. NO. 1 or SEQ. ID. NO. 3.
- 5 3. A DNA sequence consisting essentially of SEQ. ID. NO. 1 or SEQ. ID. NO. 3, said DNA encoding a polypeptide, said polypeptide consisting essentially of SEQ. ID. NO. 2 or SEQ. ID. NO. 4.
4. A DNA sequence that hybridizes to at least a fragment of SEQ. ID NO. 1 or SEQ. ID NO. 3, said fragment comprising at least 20 consecutive bases, said DNA sequence encoding a  
10 polypeptide that is at least 30% homologous with an active site of TRELL.
5. A DNA sequence according to claim 2 wherein said sequence consists essentially of SEQ. ID. NO. 1 or SEQ. ID. NO. 3 with conservative substitutions, alterations or deletions.
6. A recombinant DNA molecule comprising a DNA sequence encoding TRELL, said  
15 sequence operatively linked to an expression control sequence.
7. The molecule of claim 6 comprising SEQ. ID. NO. 1 or SEQ. ID. NO. 3.
8. A host transformed with a recombinant DNA molecule of claim 6 or 7.
9. A DNA sequence encoding TRELL having the amino acid sequence of SEQ. ID. NO. 2 or SEQ. ID. NO 4.
- 20 10. A method for producing substantially pure TRELL comprising the step of culturing the unicellular host of claim 8.

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11. TRELL essentially free of normally associated animal proteins.
12. The TRELL of claim 11 consisting essentially of SEQ. ID. NO. 2 or SEQ. ID. NO. 4.
13. A pharmaceutical composition comprising a therapeutically effective amount of TRELL or an active fragment thereof, and a pharmaceutically acceptable carrier.
- 5 14. A method for preventing or reducing the severity of an autoimmune disease comprising the step of administering a therapeutically effective amount of a pharmaceutical composition according to claim 13.
15. The pharmaceutical composition of claim 13 wherein said TRELL or active fragment thereof comprises SEQ. ID. NO. 2, or SEQ. ID. NO. 4, or a biologically active fragment thereof.  
10
16. A method for preventing or reducing the severity of an immune response to a tissue graft comprising the step of administering a therapeutically effective amount of a pharmaceutical composition according to claim 13.
17. A method for stimulating the immune system comprising administering the composition of claim 13.  
15
18. A method for suppressing the immune system comprising administering an effective amount of the pharmaceutical composition according to claim 13.
19. A method for treating cancer comprising administering a therapeutically effective amount of the pharmaceutical composition according to claim 13.
- 20 20. A method for identifying a receptor for TRELL comprising:
  - a. providing TRELL or a fragment thereof,
  - b. labeling said TRELL or fragment thereof with a detectable label;

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- c. screening a composition to detect receptors which bind to the detectably labeled TRELL of step b.
21. A soluble biologically active fragment of the TRELL of claim 11.
22. A polypeptide comprising an amino acid sequence that is encoded by a DNA selected from the group consisting of:
- a. a DNA sequence comprising SEQ. ID. NO. 1 or SEQ. ID. NO. 3;
  - b. a DNA sequence that hybridizes to the DNA defined in a. and coding on expression for a polypeptide that is at least 40% homologous with the TRELL of claim 12.
23. An antibody preparation that is reactive to TRELL or its receptor or biologically active fragments thereof.
24. The antibody preparation of claim 23 comprising monoclonal antibodies.
25. A method for producing an antibody preparation reactive to TRELL or its receptor comprising the step of immunizing an organism with TRELL or its receptor, or an antigenic fragment thereof.
26. An antisense nucleic acid against TRELL comprising a nucleic acid sequence hybridizing to at least a portion of SEQ. ID. NO. 1 or SEQ. ID. NO. 3.
27. A pharmaceutical composition comprising an antibody preparation according to claim 24.
28. A method of expressing a gene in a mammalian cell comprising:
- a. introducing a gene encoding TRELL into a cell;
  - b. allowing said cell to live under conditions such that said gene is expressed in said mammal.

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29. A method of treating a disorder related to TRELL in a mammal
- a. introducing into a cell a therapeutically effective amount of a vector comprising a gene encoding TRELL; and
  - b. expressing said gene in said mammalian cell.
- 5 30. The method of claim 29 wherein the mammal is a human.
31. The method of claim 29 wherein said vector is a virus.
32. A method of inducing cell death comprising the administration of an agent capable of interfering with the binding of TRELL to a receptor.
33. The method of claim 32 further comprising the administration of interfereon- $\gamma$ .
- 10 34. A method of treating, suppressing or altering an immune response involving a signalling pathway between TRELL and its receptor, said method comprising the step of administering an effective amount of an agent capable of interfering with the association between TRELL and its receptor.
- 15 35. The method of claim 35 wherein said immune response involves human adenocarcinoma cells.

## Comparison of Mouse and Human TNF Family Related Proteins (TFRPs)

human	1	MSLLDFEISA	RRLPLRSLG	SRDGGAVRQA	QPPAPMAARR	SQRRRGRERGE	50
mouse		.....	.....	.....	.....	.....	
human	51	PGTALLVPLA	LGLGLALACL	GLLLAVVSLG	SRASLSAQEP	AQEELVAEED	100
mouse		.....V	LSLGLALACL	GLLLVVVSLG	SWATLSAQEP	SQEELTAEDR	
human	101	QDPSELNPQT	EESQDPAPFL	NRLVRPRRSA	PKGRKTRARR	AIAAHYEVHP	150
mous		REPPELNPQT	EESQDVVPFL	EQLVRPRRSA	PKGWKARPRR	<u>AIAAHYEVHP</u>	
human	151	RPGQDGAQAG	VDGTVSGWEE	ARINSSSPLR	YNRQIGEFIV	TRAGLYYLYC	200
mouse		RPGQDGAQAG	VDGTVSGWEE	TKINSSSPLR	YDRQIGELTV	<u>IRAGLYYLYC</u>	
human	201	QVHFDEGKAV	YLKLDLLVDG	VLALRCLEEF	SATAASSLGP	QLRLCQVSGL	250
mouse		QVHFDEGKAV	YLKLDLLVNG	VLALRCLEEF	SATAASSPGP	QLRLCQVSGL	
human	251	LALRPGSSLR	IRTLPWAHLK	AAPFLTYFGL	FQVH		284
mouse		LPLRPGSSLR	IRTLPWAHLK	AAPFLTYFGL	FQVH		

FIG. 1

### Sequence Comparison of Human Ligands in the TNF Family

An alignment of 10 human members of the TNF ligand family illustrating the variations in the length of the intracellular N-terminal domains and the stalk regions spacing the C-terminal receptor binding domain from the transmembrane region (beginning just before the first beta strand). The N terminus of human FasL has been truncated. The alignment weighs cysteine conservation heavily and due to the very poor homology in certain regions between some family members, many alternative alignments can be proposed varying in the details. The bars over the sequences indicate beta strand structures in TNF and LT with the nomenclature being that used by Eck and Sprang. Canonical N-linked glycosylation sites are underlined as are probable transmembrane sequences and the disulfide linked cysteines in TNF are marked with dots. Starred sequences are motifs useful in the recognition of TNF family members.

hTNF	MSTESMIRDVELAEELPKKTGPPQSSRRCLRLSLSESLIVAGATTLECLLHFGVIGPQREEFPRDLSLI
hLT- $\alpha$	MTPPERLFLPRVCGTTLHLILLGLLAVLLPGAGGLPGVGLTPSAAQTARQHPKMHIAH
hLT- $\beta$	MGALGLEGRGRLQGRGSLLLAVAGATSLVTLILLAVPTVTLAVLALVPODQGLVTETADPGAQAQ
hFasL	...APPGTVLPCPTSVPRRPGQRRPPPPPPPLPPLPPLKXRGNHSTGLCLINMFEFVVALVGLGLGMEQLPHLQKELAELESTSQ
hTFRP	MSLLDFEISARRLLPLPRSLGSRDGGAVRQAQPPAPMAARRSQRRRRGRRGEPGTALLVPLALGLGLALACLGILLAVVSLGSRASLSAQEPAEELVAEE
hTRAIL	MAMMEVQGQPSLGGTCTLLIVFTVLLQSLCAVTVVYFETNELKQMMDKYSKSGIAC
hCD27L	MPEEGSGCSVRRRPPYGCVLRAALNPNVAGLVICLVNVCIQRFQAQQQLPLESLG--
hCD30L	MDPGLQQALNGMAPPGDTAMHVPAGSVASHLGTTSRSYFYLTATLALCLNFTVATIMVLANVQRTDSIPNSPDNVPLKGG
hCD40L	MIETYNQTSRPSAATGLPISMKIFMYLLTVFELATOMIGSALFAYVLRRLDKIEDERNLHEDFV
h4-1BBL	MEYASDASLDPEAPWPPAPRARACRVLFWALVAGLILLALLAAACVPAVELACPWAVSGARASPSGSAAS

FIG. 2A

hTNP SSPLAQAVRSSRTP-----A'-----SDKPVAVVAVPQABGQ-----A'-----LQWLNR  
hLT-α hLT-α TLKPAHLIGDPSK-QNS-----LLWRAN  
hLT-β QGLGFQKLPEEPETDLS-----PGLPAAHLIGAPLKGQ-----LGWETT  
hPasL MHTASSLEKQIGHPSPPPEKK-----ELRKVAHLTGKNSRSMP-----LEWEDT  
hTFRP DQDPSELNPQTEESQDPAPFLNLRVRRSAPKGRKTRA-----RRALAAHYEVHPRPGDGAQAGVDGT-----SGWEEA  
hTRAIL FLKEDDSYNDPNDSESNPCWQVKQLRQLVRKMLRTSEETISTVQEKQONISPLVRERGQPVAAHITGTRGRSNTLSSPNSKNEKALGRKINSWESS  
hCD27L -----WDVAELQJNHTGPPQDPR-----LYWQGG  
hCD30L NCSEDLCLILKRAPF-----KSWAYLQVAKHLNKT-----LSWNKD  
hCD40L FMKTIQRCNTGERSLSLLNCEEIKSQFEGFVCDIMLNKEETKKENSFEMQKGDQ-----NPQLAAHVISEASSKTTSV-----LQWAEK  
h4-1BBL PRLREGPELSPDDPAGLLDLRQGM-----FAQLVAQNVLIDGP-----LSWYSD  
\*\*\*\*

hTNP RANALLAN-GVELRD--NQ-LVVPSEGLYLIY-SQVLFKGGQCPSTHVLTHITISRIASV-----YQTKVN--LLSAIKS-----PCQRETPEGAEAK  
hLT-α TDRAPLQD-GFSL--NNS-LLVPTSGIYFVNSQVFSKAY-SPKAT-SSPLYLAHEVQLFSSQYPPHP--LLSSQKM--VY-PGLQE-----  
hLT-β KEQAFLT-SGTQFSDAEG--LALPDGLYLYTCLVYRGRAPGGDPQGRSVTLRSSLYRAGGAYGPGTPELLEGAETVTPVLDPARRQGYG-----  
hPasL YGIVULL--SGVKYK--GG--LVINETGLYFVY-SKVYPRGQSCNNQPLSHKVYERN--SK-----YPQDL--VMMEGKM--MSY--CTTGQ-----  
hTFRP RINSSSFLRYNRQI--GE--PIVTRAGLYLY-CQVHFDEGKAVYKLDLLVDGVALRCLDEEFSATAASSLGPQLRL-----CQVSGLL  
hTRAIL RSGHSFLSNHLRN--GE--LVIHEKGFYIY-SQYVPRFQEEIKENTQDKQWQYIYKYS--YDPDI--LLMKSARNS-----CTIV-----  
hCD27L PALGRSPLHGPDL-DKGQ--LRIHRDGIYMHVH-QVTLAI--CSSTASRHHPTTAVGICSPASRSIS-----LLRLSFHQG-----VCESGMOTKHVYQNLQFL-----  
hCD30L G-----ILHGVRYQD-GN--LVIQFPGLYFII-CQLQFLVQ-CPNNSVDLKLLELKNHKK--QALVT-----VCESGMOTKHVYQNLQFL-----  
hCD40L GYTTMSNNLVTL--ENGKQ-LTVKRGGLYIYA-QVTF-----CSNREASSQAPFIASLCLKSPGRFERI-----LLRAAN--THSSAKPCGQSIH-----  
h4-1BBL DGAGSSYLSQGLRYEEDKKELWDSPLGYVYVLELKLSPFTTNTQHKVQGWVSLVLQAKP--QVDDFDN-----LAL-----TVELP-PCSMENKLVDRS-  
\*\*\*\*

hTNP P-WYEPIYLGGVFQLEKGDRLSABEINRPDYLDFAESGQ-----H-----VYFGIIL  
hLT-α P-WLHSMYHGAFAQLTQGDQLSTHTDGIPLHLV--SPS--TVFFGAPAL  
hLT-β PLWYTSVGFGLVQLRRGERVYVNLISHPDMDPAR--GKT-FFGAVMVG  
hPasL -HWARSSYLGAVFNLTSADHLYVNVSEL--SLVNFEESQT-FFGLYKL  
hTFRP ALRPGSSLRIRTLPAWHLKAAPFL-----T-YFGLFQVH  
hTRAIL --GLYSIYQGGIFELKENDRIFVSVTNEHLIDMDHEA--S-FFGAPFLVG  
hCD27L -SRLTPLARGDTLCTNLGTLLPSR-NTDE-----T-FFGVQWVRP  
hCD30L --LDYLQVNTTISVNVDTFYIDTST-FPLE-NVL-----S-IFLYSNSD  
hCD40L -----LGGVPELQPGASVFVNVTDPSQVSHG--TGFTS-FGLLKL  
h4-1BBL --WSQLLLLLKAGHRLSVGLRAYLHGAQDAYRDWELSYPNITS-FGLFLVKPDNPWE

FIG. 2B

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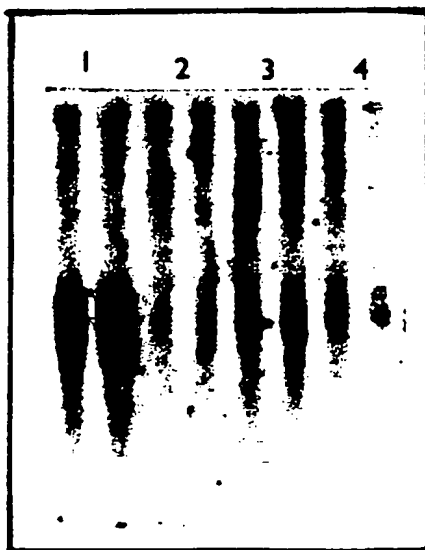


FIG. 3

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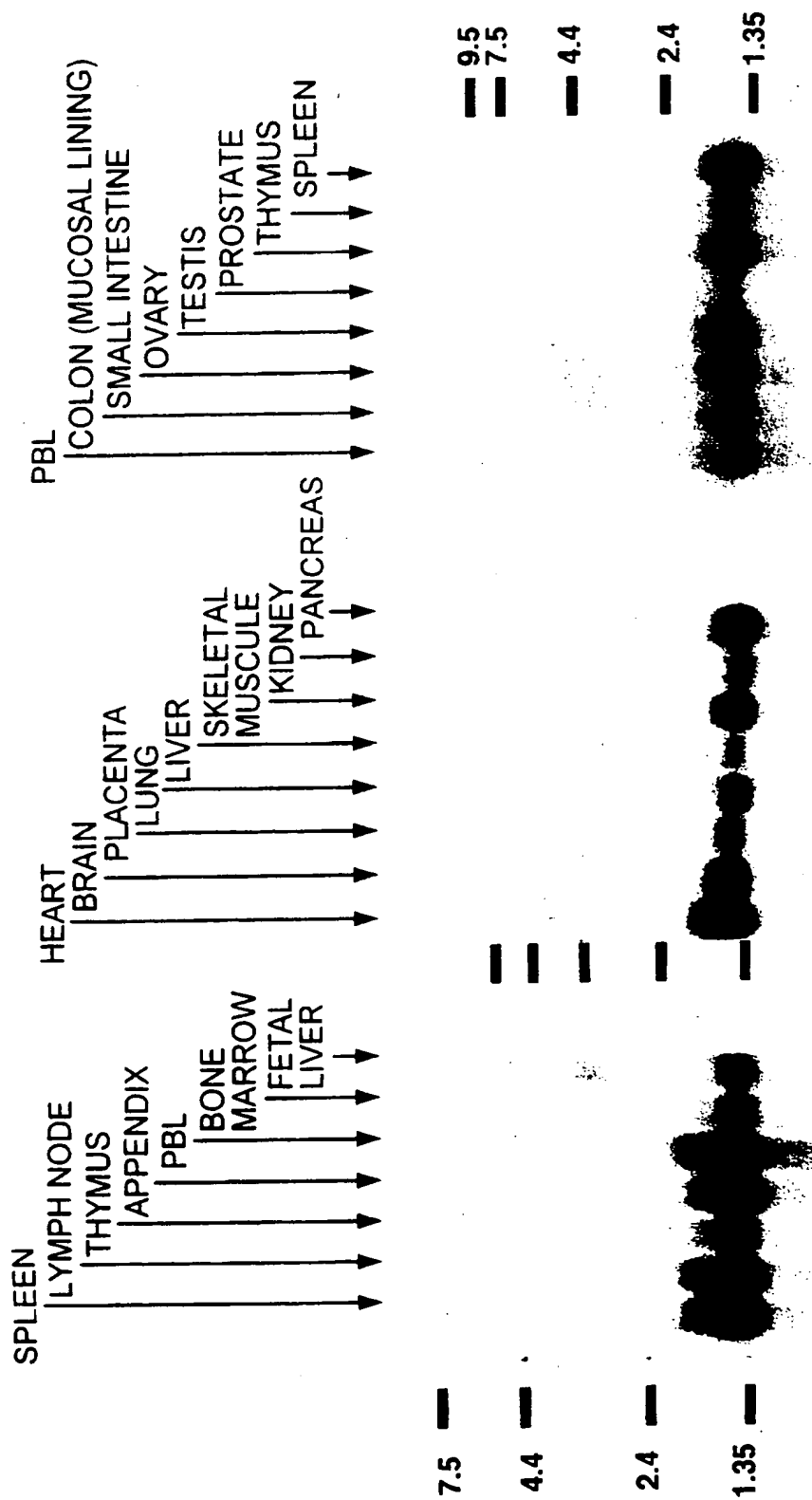


FIG. 4

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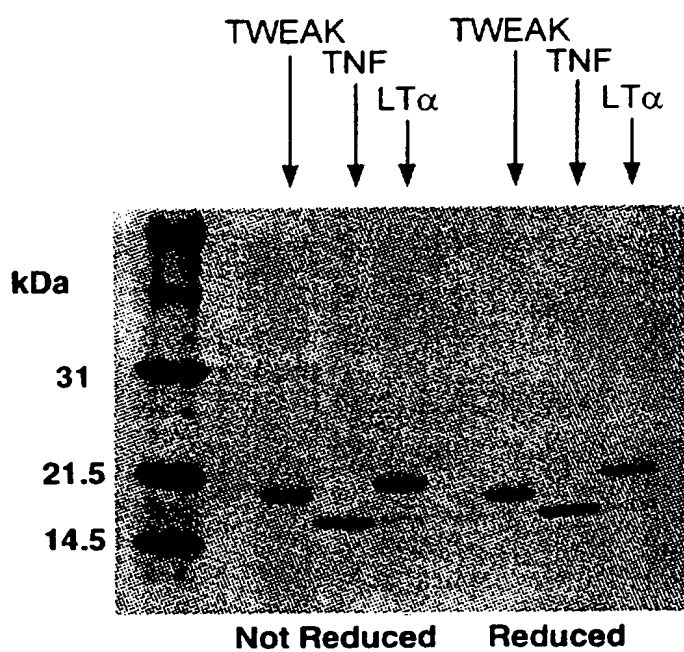


FIG. 5

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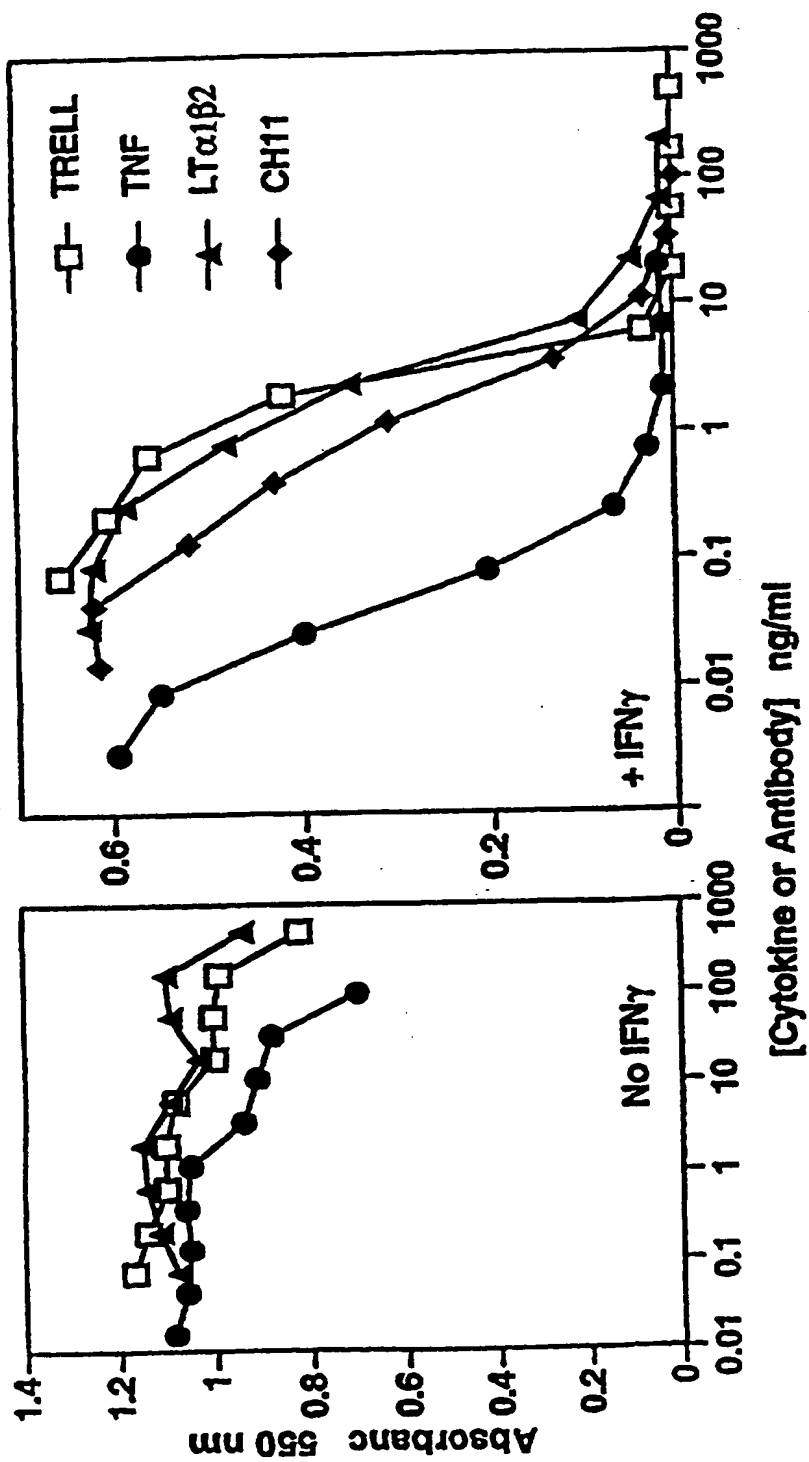


FIG. 6A



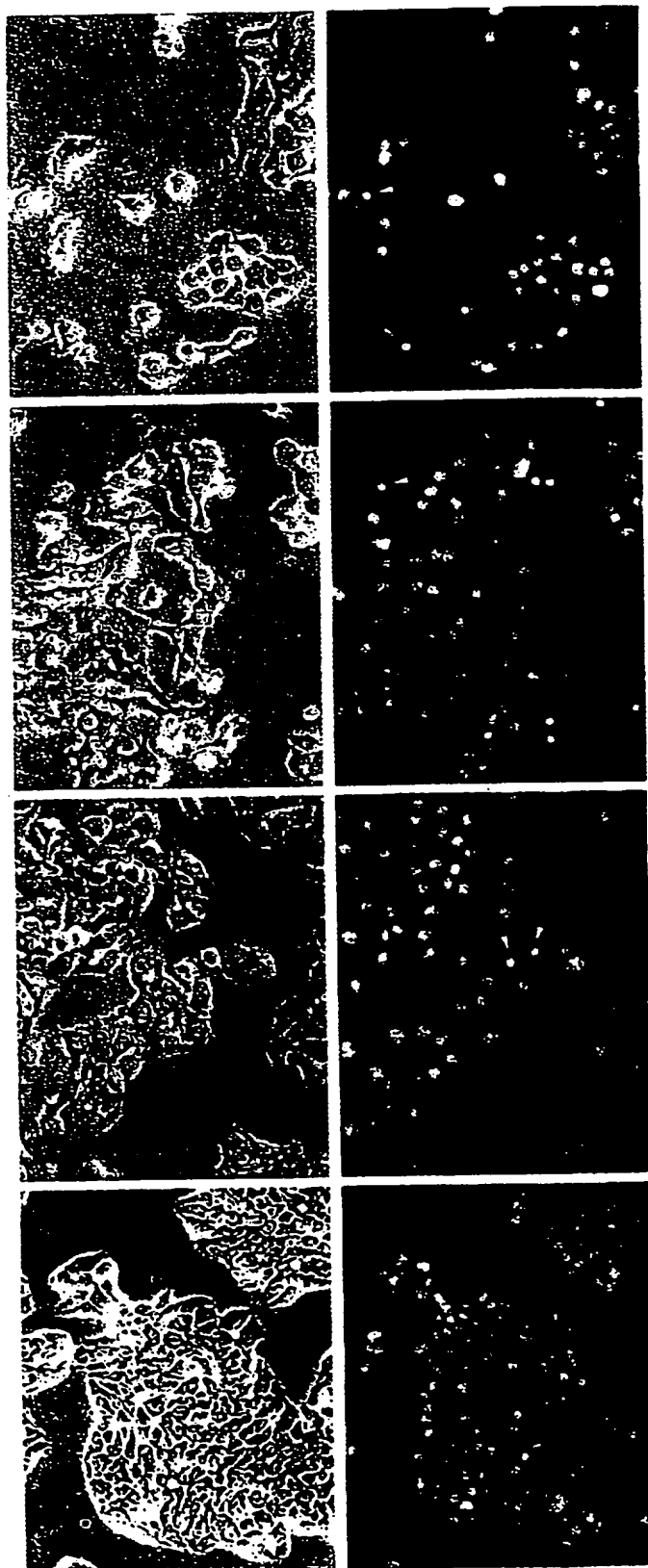


FIG. 6B

# INTERNATIONAL SEARCH REPORT

Intern: al Application No  
PCT/US 97/13945

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C12N15/28 C07K14/525 G01N33/68 C07K16/24 C12N15/11  
A61K48/00 C12N5/10 A61K39/395 A61K38/19 C07K14/705  
C12N15/12

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07K C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	L. HILLIER ET AL: "The WashU-Merck EST project . yj77A08.r1 Homo sapiens cDNA clone 154742 5'" EMBL DATABASE ENTRY HS379117, ACCESSION NUMBER R55379, 28 May 1995, XP002049703 cited in the application see abstract	1
X	--- L. HILLIER ET AL: "The WashU-Merck EST project. yy19a08.s1 Homo sapiens cDNA clone 271670 3'" EMBL DATABASE ENTRY HS070272, ACCESSION NUMBER N35070, 19 January 1996, XP002049704 see abstract --- -/--	1

☒ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

### \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*Z\* document member of the same patent family

Date of the actual completion of the international search

10 December 1997

Date of mailing of the international search report

07.01.98

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Le Cornec, N

# INTERNATIONAL SEARCH REPORT

Internat'l Application No  
PCT/US 97/13945

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	J,L. BROWNING ET AL: "Characterization of surface Lymphotoxin forms.Use of specific monoclonal antibodies and soluble receptors" JOURNAL OF IMMUNOLOGY., vol. 154, 1995, BALTIMORE US, pages 33-46, XP002049706 cited in the application see the whole document ---	23-25
A	WILEY S R ET AL: "IDENTIFICATION AND CHARACTERIZATION OF A NEW MEMBER OF THE TNF FAMILY THAT INDUCES APOPTOSIS" IMMUNITY, vol. 3, no. 6, December 1995, pages 673-682, XP000672297 ---	
P,X	M. MARRA ET AL: "The WashU-HHMI Mouse EST project. myl8d09.r1 Barstead mouse heart MPLRB3 Mus musculus cDNA clone 696209 5'" EMBL DATABASE ENTRY MMAA21610, ACCESSION NUMBER AA221610, 15 February 1997, XP002049707 see abstract -----	1

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 97/13945

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
see FURTHER INFORMATION sheet PCT/ISA/210
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 97/13945

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Remark : Although claims 14,16-19, 29-35 and 25,28, as far as in vivo methods are concerned, are directed to a method of treatment of the human/animal body (rule 39.1 IV PCT), the search has been carried out and based on the alleged effects of the compound/composition.

